# SOLID POLYMER ELECTROLYTE FUEL CELL SYSTEM


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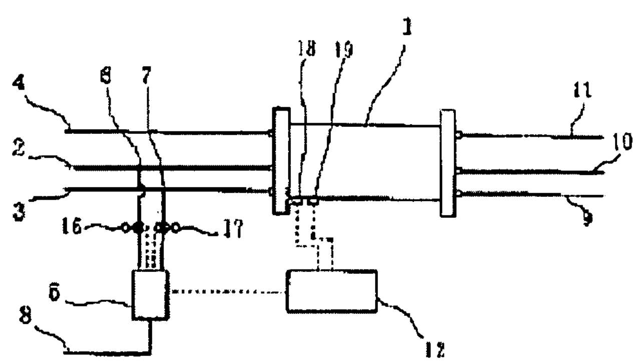
Abstract of **JP11162490**

PROBLEM TO BE SOLVED: To provide a solid polymer electrolyte fuel cell system capable of controlling the humidification quantity to reaction gas so that fuel cells can be operated in the optimum state even when the operating condition such as the load condition is changed. SOLUTION: A fuel feed pipe 2, an air feed pipe 3, a cooling water feed pipe 4, a fuel gas discharge pipe 10, an air discharge pipe 9 and a cooling water discharge pipe 11 are connected to a cell stack 1 of solid polymer electrolyte fuel cells. A steam generating device 5 is connected to the fuel feed pipe 2 and the air feed pipe 3. Flow control valves 16, 17 are provided on the passages to the fuel feed pipe 2 and the air feed pipe 3 from the steam generating device 5. A water feed pipe 8 is connected to the steam generating device 5, and a resistance value sensor 18 and a voltage sensor 19 are assembled in the cell stack 1. The resistance value sensor 18 and the voltage sensor 19 are connected to a control device 12, and the control device 12 is connected to the steam generating device 5.

JAPANESE [JP,11-162490,A]



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## CLAIMS

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[Claim(s)]
[Claim 1] The cell stack which has at least one cell with which the electrolyte membrane which consists of a solid-state macromolecule has been arranged between a fuel electrode and an oxidizer pole, In the solid-state polyelectrolyte mold fuel cell system equipped with the fuel feeding pipe which supplies fuel gas to said fuel electrode, and the oxidizer supply pipe which supplies oxidant gas to said oxidizer pole The solid-state polyelectrolyte mold fuel cell system characterized by establishing a humidification means to supply a steam or the atomized water to either [ at least ] said fuel feeding pipe or said oxidizer supply pipe.
[Claim 2] The solid-state polyelectrolyte mold fuel cell system according to claim 1 characterized by having the control unit which performs feedback control to the amount of supply of the steam by said humidification means, or the atomized water based on the operating state of said cell stack.
[Claim 3] The operating state of said cell stack is a solid-state polyelectrolyte mold fuel cell system according to claim 2 characterized by being the electric resistance value of said electrolyte membrane, and the output voltage of a cell.
[Claim 4] The operating state of said cell stack is a solid-state polyelectrolyte mold fuel cell system according to claim 2 characterized by being the burden of a cell stack.
[Claim 5] The operating state of said cell stack is a solid-state polyelectrolyte mold fuel cell system according to claim 2 characterized by being the fuel gas flow rate which flows said fuel feeding pipe.
[Claim 6] The operating state of said cell stack is a solid-state polyelectrolyte mold fuel cell system according to claim 2 characterized by being the oxidant gas flow rate which flows said oxidizer supply pipe.
[Claim 7] The solid-state polyelectrolyte mold fuel cell system according to claim 1 characterized by having the control unit which performs feedback control to the amount of supply of the steam by said humidification means, or the amount of supply of the atomized water based on the humidity which the humidity sensor was formed in the downstream of said humidification means, and was detected by said humidity sensor.
[Claim 8] Said humidification means is a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7 characterized by being constituted by the nozzle which spouts the steam prepared at least in one of said fuel feeding pipe

and said oxidizer supply pipe, and the steam generator formed in the upstream.
[Claim 9] Said humidification means is a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7 characterized by being constituted with the spraying nozzle prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the pressurizer which pressurizes the water prepared in the upstream.
[Claim 10] Said humidification means is a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7 characterized by being constituted with the ultrasonic spraying nozzle prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the pump which supplies the water prepared in the upstream.
[Claim 11] Said humidification means is a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7 characterized by being constituted by the nozzle which supplies water to a part for a part for the converging section prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and said converging section.
[Claim 12] Said humidification means is a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7 characterized by being constituted with the rotating disc prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, the nozzle which supplies water toward said rotating disc, and the pump which supplies water to the upstream of said nozzle.
[Claim 13] A solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-12 to which passage of the cooling water of said cell stack is characterized by connecting with the supply way of the water to said humidification means.
[Claim 14] A solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-12 to which passage of the generation water produced by the reaction within said cell stack is characterized by connecting with the supply way of the water to said humidification means.
[Claim 15] A solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-14 characterized by having two or more said cell stacks.
[Claim 16] A solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-15 characterized by establishing a preheating means to heat said fuel gas and said oxidant gas beforehand with the heat generated with a fuel cell.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the solid-state polyelectrolyte mold fuel cell system which used the solid-state poly membrane as an electrolyte, and relates to the maintenance function of the humidification condition of a solid-state poly membrane, and the solid-state polyelectrolyte mold fuel cell system which improved to space efficiency.
[0002]
[Description of the Prior Art] By making fuels, such as hydrogen, and oxidizers, such as air, react electrochemically, a fuel cell is equipment which transforms into direct electrical energy the chemical energy which a fuel has. Also in it, the solid-state polyelectrolyte mold fuel cell which used macromolecule ion exchange membrane for the electrolyte has the descriptions, like that power density is high, that structure is simple, and operating temperature is comparatively low, and the expectation for much more ED is growing.
[0003] The basic configuration of the cell in such a solid-state polyelectrolyte mold fuel cell is explained below according to drawing 14 . That is, the solid-state poly membrane 102 which has ion conductivity is inserted, the anode electrode 103 and the cathode electrode 104 are arranged, and the cell 101 is constituted. The anode electrode 103 is formed of anode catalyst bed 103a and anode porosity carbon plate 103b. The cathode electrode 104 is formed of cathode catalyst bed 104a and cathode porosity carbon plate 104b.
[0004] The separator 105 of gas impermeability which has conductivity is arranged at the upper and lower sides of this cell 101. The slots 103c and 104c for supplying reactant gas to the anode electrode 103 and the cathode electrode 104 are established in this separator 105.
[0005] In the above solid-state polyelectrolyte mold fuel cells, if fuel gas is supplied to the anode electrode 103 and oxidant gas is supplied to the cathode electrode 104, respectively, electromotive force will arise as follows according to electrochemical reaction in inter-electrode [ of the pair of a cell 101 ]. That is, first, although hydrogen is used as fuel gas and air is usually used as oxidant gas, if hydrogen is supplied to the anode electrode 103 and air is supplied to the cathode electrode 104, respectively, with the anode electrode 103, the supplied hydrogen will be dissociated into a hydrogen ion and an electron in anode catalyst bed 103a.

And a hydrogen ion passes along the solid-state poly membrane 102, and an electron passes along an external circuit and moves to the cathode electrode 104, respectively.
[0006] On the other hand in the cathode electrode 104, the oxygen, the above-mentioned hydrogen ion, and electron in the supplied air react in cathode catalyst bed 104a, and water is generated. At this time, the electron passing through an external circuit serves as a current, and can supply power. That is, in the anode electrode 103 and the cathode electrode 104, the reaction shown in the following formulas 1 and a formula 2, respectively advances. In addition, the generated water is discharged out of a cell with a unconverted gas.
[0007]
[Formula 1]
anode reaction: -- H2 ->2H++2e- the -- type 1 -- [Formula 2]
Cathode reaction: 2H++1/2O2+2e-->H2 O In the -- type 2 and time, since the electromotive force of a cell 101 is as low as less than [ 1V ], the usual practical use mold fuel cell system has the cell stack which carried out the laminating of the cell 101 of dozens - 100 numbers through the above-mentioned separator 105, and the generation of electrical energy by this cell stack is performed. And although the temperature up of such a cell stack will be carried out with a generation of electrical energy, in order to control this temperature up, the cooling plate is inserted for every cell of several sheets.
[0008] As a solid-state poly membrane 102 which has the ion conductivity used for the above solid-state polyelectrolyte mold fuel cells, the perfluoro ROKABON sulfonic acid (Nafion R : U.S., Du Pont) which is the proton exchange film is known, for example. While this film functions as an ion conductivity electrolyte by having and carrying out the saturation water of the exchange group of a hydrogen ion into a molecule, it also has the function to separate a fuel and an oxidizer. On the contrary, if membranous moisture content decreases, ion resistance will become high, the crossover which an oxidizing agent mixes with a fuel occurs, and a generation of electrical energy by the cell becomes impossible. For this reason, as for a solid-state poly membrane, what is considered as saturation water is desirable.
[0009] When the hydrogen ion separated with the anode electrode by generation of electrical energy moves to a cathode electrode through a solid-state poly membrane, in order that water may also move together on the other hand, in an anode electrode side, it is tended to dry a solid-state poly membrane. If there are few steams with which the fuel to supply or air is included, it is tended near [ each ] a reactant gas entry moreover, to dry a solid-state poly membrane. Generally from the above-mentioned reason, supplying the fuel humidified beforehand and an oxidizer is performed to the solid-state polyelectrolyte mold fuel cell.
[0010] As this humidification approach, various attempts are made from the former. The fuel cell shown in U.S. Pat. No. 5,284,718 is one of those are most generally known. This establishes a humidification field in the interior of a cell stack, as shown in drawing 15 . That is, fuel gas and oxidant gas are humidified in a humidification field with a humidifier, before going into the reaction field which is

the cell section. This humidification approach makes reactant gas adjoin water through semipermeable membrane, and when a water molecule passes semipermeable membrane, it humidifies. The amount of humidification is influenced by the differential pressure of water and reactant gas, temperature, the physical-properties value of a semipermeable membrane proper, area, thickness, and number of sheets.
[0011] Moreover, the humidification approach proposed in JP,7-29591,A as other conventional techniques is learned. As it is generally called the bubbler method and is shown in drawing 16 , this installs water tank T equipped with the heater in fuel Rhine, and humidifies by passing fuel gas in water. The amount of humidification is influenced by the amount of fuel gas, the temperature of the water in a tank, and the geometry of a tank.
[0012] Furthermore, the thing using the ultrasonic vibrator proposed in JP,6-231788,A as other conventional techniques is known. As shown in drawing 17 , this approach installs the ultrasonic vibrator S connected to the power unit P in the interior of the tank T of water, humidifies the reactant gas which is atomizing the water by the supersonic wave and entered from reactant gas entry I, and discharges it from the reactant gas outlet O. The amount of humidification is influenced by the output of an ultrasonic vibrator S.
[0013]
[Problem(s) to be Solved by the Invention] However, there were the following troubles in the above conventional solid-state polyelectrolyte mold fuel cell systems.
[0014] (1) By the method with the humidifier using the trouble semipermeable membrane by the humidifier method using semipermeable membrane, since it is necessary to build a humidifier into the interior of a cell stack, the whole cell stack becomes large and weight-izes.
[0015] Moreover, in order to make a humidification condition the optimal, it is necessary to control the amount of humidification according to an operation situation. However, by the method humidified in a humidification field before putting fuel gas and oxidant gas into a reaction field, control of the amount of humidification becomes very difficult. It is because it is impossible practically to be able to change neither temperature nor the reagent-gas-pressure force a lot, and to change the area and the number of sheets of the reaction film when some load conditions are set up.
[0016] Therefore, in this method, it becomes impossible [ the amount of humidification ] for designing with allowances so that relative humidity may always become 100%, and passing gas with low relative humidity somewhat according to an operation situation. Moreover, with this method, they are a lifting and a cone about the cell performance degradation there are too many amounts of humidification and according to the flooding of a cell contact layer.
[0017] (2) In the humidification method by the trouble bubbler by the bubbler method, since there is no humidification section in a cell stack, there is no problem of enlargement of a cell stack or weight-izing. However, since still bigger water tank T is needed as a humidifier, it enlarges and the whole system weight-izes. Moreover, since the electrical and electric equipment generated by the cell will be

used when using electric heater H as a heat source, there is a problem of dropping the effectiveness of a system. Moreover, in order to use the heat generated in reaction time by the cell as a heat source, a big heat exchanger is needed.
[0018] Furthermore, although control of the amount of humidification cannot but correspond by changing the temperature of the water in water tank T in some decided load conditions, good responsibility cannot expect it easily from the amount of the water in water tank T being large, and the heat capacity of the water tank T itself being large. Moreover, since the temperature of reactant gas is decided by temperature of a bubbler in the case of this method, it is freely uncontrollable.
[0019] (3) A degree of freedom is [ method / by the trouble supersonic wave by the ultrasonic sensing method / humidification / a bubbler method ] comparatively large, and since the amount of humidification is controllable with the output of an ultrasonic vibrator, as for the temperature of reactant gas, it is possible to make it change independently. However, to water tank T being required, it is unchanging, and a problem is in points, such as system-wide enlargement and weight-izing. Moreover, a response becomes slow, although it is not a bubbler method since a cell will be supplied after drawing reactant gas in water tank T specially and making it mix with waterdrop in order to carry the water atomized by the supersonic wave.

[0020] (4) Although three common conventional examples of the trouble above are typical, the common fundamental concept of these methods is supplied to a cell, after introducing reactant gas in a humidifier and making it mix. However, since there is almost no flow in a steam side when it is made this method, the rate of mixing becomes slow. Therefore, in order to make the mixed state into sufficient thing, a big tooth space is needed.
[0021] This invention is proposed in order to solve the trouble of the above conventional techniques, and even if it gives moderate moisture to the solid-state polyelectrolyte film and actuation conditions, such as load conditions, change, the purpose is in offer the solid-state polyelectrolyte mold fuel cell system which can control the amount of humidification to reactant gas so that it can operate in the condition optimal as a fuel cell.
[0022] Moreover, other purposes of this invention are to offer the solid-state polyelectrolyte mold fuel cell system in which a miniaturization, lightweight-izing, and low-cost-izing are possible.
[0023]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention has the following technical features in the solid-state polyelectrolyte mold fuel cell system by which the electrolyte membrane which consists of a solid-state macromolecule was equipped with the cell stack which has at least one cell arranged between a fuel electrode and an oxidizer pole, the fuel feeding pipe which supplies fuel gas to said fuel electrode, and the oxidizer supply pipe which supplies oxidant gas to said oxidizer pole.
[0024] That is, invention according to claim 1 is characterized by establishing a humidification means to supply a steam or the atomized water to either [ at least ] said fuel feeding pipe or said oxidizer supply pipe. In the above invention according

to claim 1, since the amount of humidification is controllable to arbitration with a humidification means, when [ which is the need ] only a complement humidifies reactant gas by the way, the good positive humidification of responsibility is attained and a cell stack can be maintained to the always optimal operational status. Furthermore, since there is the rate of flow quick enough in the oxidant gas and the steam in the fuel gas in a fuel feeding pipe, and an oxidizer supply pipe and the rate of mixing becomes quick, neither a big humidifier nor a big bubbler is needed, but a compact and lightweight system configuration becomes possible.

[0025] Invention according to claim 2 is characterized by having the control unit which performs feedback control to the amount of supply of the steam by said humidification means, or the atomized water based on the operating state of said cell stack in a solid-state polyelectrolyte mold fuel cell system according to claim 1. In the above invention according to claim 2, it can supervise in what kind of condition the cell is operating, humidification [ what ] can judge the need to reactant gas in the condition, it can be told to a humidification means, and required humidification can be performed. This becomes possible to maintain a fuel cell to the always optimal operational status.

[0026] Invention according to claim 3 is characterized by the operating states of said cell stack being the electric resistance value of said electrolyte membrane, and the output voltage of a cell in a solid-state polyelectrolyte mold fuel cell system according to claim 2. If an electric resistance value is low when the film is generally damp enough as a film property, and the film is further damp with the above invention according to claim 3 to the substrate layer on the catalyst bed which gets wet too much and approaches, or its outside, since the diffusion to the film surface of reactant gas is checked, the so-called FURATTINGU phenomenon arises and the cell engine performance falls remarkably, a generation-of-electrical-energy electrical potential difference will fall remarkably. When it is judged as desiccation feeling and the amount of humidification is increased, when an electric resistance value increases, a membrane resistance value is low and output voltage has fallen from this film property, control which gets wet, judges it as **** and stops the amount of humidification is performed. Thus, if it controls, operation is continuable by making a cell into the always optimal humidification condition.

[0027] Invention according to claim 4 is characterized by the operating state of said cell stack being the burden of a cell stack in a solid-state polyelectrolyte mold fuel cell system according to claim 2. In the above invention according to claim 4, the burden of a cell, i.e., the generation-of-electrical-energy output of a cell, is in proportionality mostly with the amount of reactant gas. Moreover, the amount of reactant gas and the amount of humidification are also in proportionality mostly. Therefore, if a sensor detects the burden of a cell, the required amount of humidification can be determined easily. Moreover, since the control unit always grasps the required burden demanded from a use side when operating a system, even if it is the case where especially a sensor is not formed, practically sufficient control of it is attained.

[0028] Invention according to claim 5 is characterized by the operating state of said cell stack being a fuel gas flow rate which flows said fuel feeding pipe in a solid-state polyelectrolyte mold fuel cell system according to claim 2. In the above

invention according to claim 5, if a fuel gas flow rate is measured directly, based on this, the amount of humidification of fuel gas can mainly be determined. Moreover, it becomes possible [ a flow rate ], since each other has a fuel flow and an oxidizer flow rate mostly at proportionality to determine the amount of humidification of oxidant gas based on a fuel gas flow rate. Furthermore, since the control unit always grasps, even if a required fuel gas flow rate does not form especially a sensor, practically sufficient control of it is attained.
[0029] In invention according to claim 6, the operating state of said cell stack is characterized by being the oxidant gas flow rate which flows said oxidizer supply pipe in a solid-state polyelectrolyte mold fuel cell system according to claim 2. In the above invention according to claim 6, if an air content is measured directly on an oxidant gas flow rate and a general target, based on this, the amount of humidification by the side of air can mainly be determined. moreover, a fuel gas flow rate and an oxidant gas flow rate are mutual -- since it is in proportionality mostly, it also becomes possible to determine the amount of humidification of both gas. Furthermore, since the control unit always grasps the required fuel gas flow rate, even if it does not form especially a sensor, practically sufficient control is attained.
[0030] In a solid-state polyelectrolyte mold fuel cell system according to claim 1, a humidity sensor is formed in the downstream of said humidification means, and invention according to claim 7 is characterized by having the control unit which performs feedback control to the amount of supply of the steam by said humidification means, or the amount of supply of the atomized water based on the humidity detected by said humidity sensor. In the above invention according to claim 7, a humidity sensor is formed in the downstream of the supply means of a steam or the atomized water, with this humidity sensor, the humidity of reactant gas after being humidified is measured, it judges whether delivery and a control unit are humidity with proper it about it at a control unit, and that amount of supply is directed to the supply means of a steam or the atomized water. Thereby, reactant gas is humidified proper and it becomes possible to maintain a fuel cell to the always optimal operational status.
[0031] Invention according to claim 8 is characterized by constituting said humidification means by the nozzle which spouts the steam prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the steam generator formed in the upstream in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 8, the steam generated with the steam generator blows off from a nozzle to reactant gas, it is mixed and reactant gas is humidified. At this time, since mixed humidification is compulsorily carried out by the quick rate of flow, compared with the case of the humidification which makes diffusion a subject, a humidification means can be far used as a compact.
[0032] Invention according to claim 9 is characterized by constituting said humidification means with the spraying nozzle prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the pressurizer which pressurizes the water prepared in the upstream in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim

9, the water pressurized by the booster pump is introduced into a spraying nozzle, and water is atomized. The atomized water is fully as small as dozens of microns, within reactant gas, it evaporates immediately, and it is mixed and the diameter of a drop humidifies it. At this time, since mixed humidification is compulsorily carried out by the quick rate of flow, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact.
[0033] Invention according to claim 10 is characterized by constituting said humidification means with the ultrasonic spraying nozzle prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the pump which supplies the water prepared in the upstream in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 10, since the diameter of a drop is atomized by the ultrasonic vibrator to dozens of microns, within reactant gas, it evaporates immediately, and it is mixed and the water supplied to the ultrasonic spraying nozzle is humidified. Since mixed humidification is compulsorily carried out by the quick rate of flow inside reactant gas, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact.
[0034] Invention according to claim 11 is characterized by said humidification means being constituted by the nozzle which supplies water to a part for a part for the converging section prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and said converging section in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 11, reactant gas is that the increase of the rate of flow and a pressure decline by part for a converging section, attracts water from a nozzle and atomizes water by the big speed difference. Within reactant gas, the atomized water evaporates immediately, and it is mixed and it is humidified. Thus, since mixed humidification is compulsorily carried out by the quick rate of flow inside reactant gas, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact. Furthermore, since a pump etc. becomes unnecessary, much more miniaturization is attained.
[0035] Invention according to claim 12 is characterized by constituting said humidification means with the rotating disc prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, the nozzle which supplies water toward said rotating disc, and the pump which supplies water to the upstream of said nozzle in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 12, water is atomized using the exfoliation phenomenon of the water from the disk by the centrifugal force by rotating a rotating disc at high speed and supplying water to the disk. The atomized water evaporates immediately within surrounding reactant gas, and humidifies reactant gas. Since mixed humidification is compulsorily carried out by the quick rate of flow inside reactant gas, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact.
[0036] Invention according to claim 13 is characterized by connecting the passage of the cooling water of said cell stack on the supply way of the water to said humidification means in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-12. In the above invention according to claim 13, since the

cooling water currently circulated in order to cool a fuel cell is used as a source of humidification, while being cooled to reactant gas beyond the need like [ in the case of using the water introduced from the exterior as it is ] is prevented, it becomes unnecessary [ preheating equipment ]. Therefore, a simpler and compact system becomes possible.
[0037] Invention according to claim 14 is characterized by connecting to the supply way of the water to said humidification means the passage of the generation water produced by the reaction within said cell stack in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-12. In the above invention according to claim 14, since water is surely generated at the time of a generation of electrical energy, when a fuel cell uses this as a source of humidification, it becomes unnecessary to newly carry out additional supply of the water from the exterior, and a system is simplified further.
[0038] Invention according to claim 15 is characterized by equipping any 1 term of claims 1-14 with two or more said cell stacks in the solid-state polyelectrolyte mold fuel cell system of a publication. In the above invention according to claim 15, since it is not necessary to form a humidification means in each and can respond with one humidification means even if it has two or more cell stacks, it becomes possible to miniaturize a system more.
[0039] Invention according to claim 16 is characterized by establishing a preheating means to heat said fuel gas and said oxidant gas beforehand with the heat generated with a fuel cell in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-15. In the above invention according to claim 16, since the preheating of the reactant gas supplied to a cell stack is carried out by the preheating means, the steam or the atomized water for humidification is not condensed within a supply pipe. Moreover, since it can respond to wide range cell operating-temperature conditions, effective humidification is attained.
[0040]
[Embodiment of the Invention] The gestalt of operation of this invention is explained below according to a drawing.
[0041] (1) Explain the gestalt of the operation corresponding to invention of one to gestalt (configuration) claim 3 publication of the 1st operation below according to drawing 1 and drawing 2 . That is, as shown in drawing 1 , the fuel feeding pipe 2 which supplies the hydrogen which is fuel gas, and the air supply tubing 3 which supplies the air which is oxidant gas are connected to the cell stack 1 of a solid-state polyelectrolyte mold fuel cell. Moreover, the cooling water supply pipe 4 is connected to the cell stack 1.
[0042] The steam generator 5 which supplies a steam is connected to these fuel feeding pipes 2 and air supply tubing 3. Here, 6 in drawing and 7 show the entry where a steam blows off in a fuel feeding pipe 2 and the air supply tubing 3, respectively. Flow control valves 16 and 17 are formed in the passage from the steam generator 5 to a fuel feeding pipe 2 and the air supply tubing 3, and it has the composition that the amount of humidification to a fuel feeding pipe 2 and the air supply tubing 3 is controllable, respectively.
[0043] And the water supply pipe 8 for supplying water is connected to the steam

generator 5. There is also an approach which may form a pump depending on the flow and pressure requirement of the reactant gas of the downstream, and pressurizes water as a pressurization means using the pressure of the reactant gas upstream in this water supply pipe 8.

[0044] Moreover, the fuel gas which was not able to react within the cell stack 1, the fuel gas exhaust pipe 10 which discharges air and the air exhaust pipe 9, and the cooling water exhaust pipe 11 which discharges cooling water are connected to the cell stack 1.

[0045] Furthermore, it considers as the sensor which acts as the monitor of the operating state of a fuel cell, and the resistance sensor 18 which detects the electric resistance value of the solid-state polyelectrolyte film, and the voltage sensor 19 which detects the output voltage of a fuel cell are included in the cell stack 1. This resistance sensor 18 and voltage sensor 19 are connected to the control unit 12. A control unit 12 judges the operating state of a cell, and it is connected to the steam generator 5 so that a steam yield can be directed.

[0046] (Operation) The operation of the gestalt of these above operations is as follows. That is, to the cell stack 1, the hydrogen which is fuel gas is supplied from a fuel feeding pipe 2, and a generation of electrical energy is performed by supplying the air which is oxidant gas from the air supply tubing 3. And with the cooling water supplied from the cooling water supply pipe 4, the heat generated inside a cell is absorbed in the form of the sensible heat of water, and a cell is held at proper temperature. Furthermore, the fuel gas and air which were not able to react within the cell stack 1 are discharged through the fuel gas exhaust pipe 10 and the air exhaust pipe 9, respectively. Moreover, cooling water is discharged through the cooling water exhaust pipe 11.

[0047] In such a generation-of-electrical-energy process, in a fuel feeding pipe 2 and the air supply tubing 3, the steam from the steam generator 5 blows off from entries 6 and 7, and fuel gas and air are humidified. A control unit 12 judges the operating state of a cell, and controls the steam amount of supply from the steam generator 5.

[0048] When an electric resistance value is high, the solid-state polyelectrolyte film is more specifically in dryness, but since the solid-state polyelectrolyte film means that it is in the condition too much of getting wet with some flooding if an electric resistance value is low and output voltage is low, the film is damp and a condition can be known with an electric resistance value and an output voltage value. therefore, suitable, when a control unit 12 directs an yield to the steam generator 5 based on the electric resistance value detected by the resistance sensor 18, and the output voltage value detected by the voltage sensor 19 -- it gets wet and a condition is maintained.

[0049] An example of the control sequence by such control unit 12 is shown in drawing 2 . In addition, a membrane resistance value sets R and an electrical-potential-difference value to V, and sets each threshold to Rs and Vs. That is, it is if the membrane resistance value R from the resistance sensor 18 and the electrical-potential-difference value V from a voltage sensor 19 are inputted into a control unit 12 (step 201). When larger than a threshold Rs, the increment command in the amount of humidification is issued for R to (step 202) and the

steam generator 5 (step 203).
[0050] And R is smaller than a threshold Rs, and when smaller than a threshold Vs, the amount reduction command of humidification is issued for the electrical-potential-difference value V to (step 204) and the steam generator 5. R is smaller than a threshold Rs, when larger than a threshold Vs, the amount of humidification of a steam generator is maintained, and the electrical-potential-difference value V serves as input waiting of the membrane resistance value R and the electrical-potential-difference value V (step 206).
[0051] (Effectiveness) Since fuel gas and the amount of humidification of air are controlled according to the gestalt of these above operations, acting as the monitor of the operating state of the cell stack 1 continuously, even if actuation conditions change, to compensate for this change, the solid-state polyelectrolyte film can be damp, a condition can be made good, and the always optimal operational status can be maintained.
[0052] Moreover, since it is not necessary to prepare a humidification part in the cell stack 1 like the above-mentioned conventional technique, the miniaturization of the cell stack 1 and lightweight-ization are attained. Furthermore, since there is the rate of flow quick enough in the oxidant gas in the fuel gas in a fuel feeding pipe 2, and the air supply tubing 3 and the rate of mixing with the steam supplied becomes quick, the need of a big humidifier, the big bubbler, etc. is not carried out, but system-wide miniaturization and lightweight-ization can be realized.
[0053] (2) Explain the gestalt of the operation corresponding to gestalt (configuration) claim 1 of the 2nd operation, claim 2, and invention according to claim 7 below according to drawing 3 . That is, humidity sensors 13 and 14 are formed in the downstream of the entries 6 and 7 of the steam with which the gestalt of this operation was prepared in a fuel feeding pipe 2 and the air supply tubing 3, respectively. And humidity sensors 13 and 14 are connected to the control unit 12. Thus, the configuration except having formed humidity sensors 13 and 14 instead of the resistance sensor 18 and the voltage sensor 19 is the same as that of the gestalt of the 1st operation of the above.
[0054] (The operation effectiveness) With the gestalt of these above operations, the steam generator 5 and flow control valves 16 and 17 are controlled by the control unit 12, acting as the monitor of the humidity measured by humidity sensors 13 and 14 so that it can maintain to the humidity to which fuel gas and air were set beforehand, while the cell stack 1 operates. Therefore, since the humidity of fuel gas and air is measured directly while the same operation effectiveness as the gestalt of the 1st operation is acquired, the required amount of humidification can be controlled more correctly.
[0055] (3) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 9 publication of the 3rd operation according to drawing 4 and drawing 5 . That is, in the gestalt of this operation, the spraying nozzle 21 is installed in the interior of a fuel feeding pipe 2. This spraying nozzle 21 is connected to high pressure pumping 20 through the water supply pipe 22, and high pressure pumping 20 is connected to the water supply pipe 8 for supplying water from the exterior. And as for high pressure pumping 20, the rotational frequency is prepared controllable by the control unit 12. Thus, the configuration except having

formed a spraying nozzle 21 and high pressure pumping 20 is the same as that of the gestalt of the 1st operation of the above instead of the steam generator 5 and flow control valves 16 and 17.

[0056] (Operation) With the gestalt of these above operations, by high pressure pumping 20, the water supplied from the water supply pipe 8 serves as high pressure, and is supplied to a spraying nozzle 21 through the water supply pipe 22. And as shown in drawing 5 , in case the spraying nozzle 21 in which high-pressure water has micropore is passed, it is atomized by the small drop of about 10 microns of diameter numbers, and is sprinkled into a fuel feeding pipe 2. The atomized drop evaporates beforehand within fuel gas, and humidifies fuel gas. Like the gestalt of the 1st operation, in a control unit 12, the required amount of humidification is judged from the operating state of a fuel cell, it is fed back to the engine speed of high pressure pumping 20, the amount of humidification at this time raises an engine speed to increase the amount of humidification, and it controls it by performing control which lowers an engine speed to decrease.

[0057] (Effectiveness) According to the gestalt of these above operations, by very simple structure and the small member, while the same operation effectiveness as the gestalt of the 1st operation is acquired, since a humidification means can be constituted, it becomes still compacter and lightweight.

[0058] (4) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 10 publication of the 4th operation according to drawing 6 and drawing 7 . That is, in the gestalt of this operation, the ultrasonic nozzle 24 is formed in two in a fuel feeding pipe. The water supply pipe 22 with which the control-of-flow bulb 23 was formed is connected to this ultrasonic nozzle 24. And the water supply pipe 22 is connected to the water supply pipe 8 for supplying water from the exterior. The ultrasonic nozzle 24 and the control-of-flow bulb 23 are connected to the control unit 12. Thus, the configuration except having formed the ultrasonic nozzle 24 and the control-of-flow bulb 23 is the same as that of the gestalt of the 1st operation of the above instead of the steam generator 5 and flow control valves 16 and 17.

[0059] (Operation) With the gestalt of these above operations, the water supplied from the water supply pipe 8 is supplied to the ultrasonic nozzle 24 through the water supply pipe 22. In the ultrasonic nozzle 24, a feedwater is atomized to 10 microns of diameter numbers, is sprinkled into a fuel feeding pipe 2 by the atomization operation by the supersonic wave, and humidifies fuel gas according to it. Like the gestalt of the 1st operation, the amount of humidification at this time judges the required amount of humidification from the operating state of the cell stack 1, and is controlled by feeding it back to the control-of-flow bulb 23. That is, when increasing the amount of humidification, bulb opening is enlarged, and the amount of humidification is controlled by performing control which makes bulb opening small to decrease.

[0060] (Effectiveness) Since according to the gestalt of these above operations high pressure pumping 20 becomes unnecessary compared with the high-pressure spraying method shown in the gestalt of the 3rd operation while the same operation effectiveness as the gestalt of the 1st operation is acquired, it can consider as a still briefer configuration and much more miniaturization can be

realized.
[0061] (5) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 11 publication of the 5th operation according to drawing 8 . Although the gestalt of this operation is the almost same configuration as the gestalt of the 4th operation of the above, it differs in that a part for a converging section 26 is prepared in a fuel feeding pipe 2, and not the ultrasonic nozzle 24 but the water spray hole 25 is formed in a part for this converging section 26. And the water supply pipe 22 is connected to this water spray hole 25.
[0062] (Operation) Fuel gas is humidified with the gestalt of these above operations, the suction effectiveness, i.e., atomizer effectiveness, of the water by the high-speed jet. That is, although the fuel which has passed along the fuel feeding pipe 2 gathers the rate of flow gradually as it approaches a part for a converging section 26, on the contrary, a pressure falls gradually and turns into the minimum pressure in a part for a converging section 26. Then, the water supplied from the water supply pipe 22 is attracted through the water spray hole 25, and is atomized and humidified by high-speed fuel gas. The amount of humidification at this time is controlled by the same control as the 4th above-mentioned example.
[0063] (Effectiveness) Since according to the gestalt of these above operations the ultrasonic nozzle 24 becomes unnecessary compared with the gestalt of the 4th operation while the same operation effectiveness as the gestalt of the 1st operation is acquired, structure can be simplified further. Moreover, since power for atomizing water is not needed other than control of a flow control valve 23, higher generating efficiency can be acquired.
[0064] (6) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 12 publication of the 6th operation according to drawing 9 . Although the gestalt of this operation is the almost same configuration as the gestalt of the 4th operation of the above, the points which have adopted the rotation atomization method differ. That is, the atomization room 29 is established in the part in a fuel feeding pipe 2, and the rotating disc 27 connected by the motor 28 into it is arranged. A taper part is prepared in this rotating disc 27, and the point of the water supply pipe 22 is arranged in the location close to a taper part.
[0065] (Operation) With the gestalt of these above operations, a rotating disc 27 rotates by the motor 28 at high speed. And by the taper part of a rotating disc 27, the water supplied from the water supply pipe 22 moves to rotating-disc 27 edge by the centrifugal-force effectiveness, serves as a drop from the edge concerned, and is sprinkled at the atomization room 29 which are some fuel feeding pipes 2. The sprinkled water evaporates as it goes to the downstream, and it humidifies fuel gas. The amount of humidification at this time is controlled by the same control as the 4th above-mentioned example.
[0066] (Effectiveness) Since according to the gestalt of these above operations the drop of a fixed particle size can be supplied according to the flow rate of broad water while the same operation effectiveness as the gestalt of the 1st operation is acquired, the humidification stabilized extremely is realizable.
[0067] (7) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 13 publication of the 7th operation according to drawing 10 .

Although the gestalt of this operation is the almost same configuration as the gestalt of the 1st operation, the points using the cooling water of a cell as humidification water differ. That is, the cooling water exhaust pipe 11 of the cell stack 1 is connected to the radiator 31 through the pump 30. This radiator 31 is connected to the cooling water supply pipe 4 through the return pipe 33. The bulb 32 for supply is formed in the cooling water supply pipe 4. Moreover, the cooling water exhaust pipe 11 is connected also to the steam generator 5 through the pump 30.
[0068] (Operation) With the gestalt of these above operations, after being sent with a pump 30, going into a radiator 31 and being cooled to laying temperature, the cooling water discharged from the cell stack 1 is again supplied to the cell stack 1 through a return pipe 33, and it circulates through it. And some circulating water is led to the steam generator 5, and it is used for humidification of reactant gas. The amount of humidification at this time is controlled by the same control as the 1st above-mentioned example. Since a circulating water flow will become less gradually if it is used for humidification, the bulb 32 for supply is opened and an insufficient part is supplied.
[0069] (Effectiveness) Since according to the gestalt of these above operations humidification water is beforehand heated by the waste heat of a cell while the same operation effectiveness as the gestalt of the 1st operation is acquired, energy required for the heating heater in the steam generator 5 etc. is reducible. Therefore, the generating efficiency of a system improves further.
[0070] (8) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 14 publication of the 8th operation according to drawing 11 . Although the gestalt of this operation is the almost same configuration as the gestalt of the 7th operation of the above, the points using the generation water generated by reaction time inside the fuel cell as humidification water differ. That is, the vapor-liquid-separation machine 34 is formed in the air exhaust pipe 9 of the cell stack 1. This vapor-liquid-separation machine 34 is connected to the steam generator 5 through the pump 30.
[0071] (Operation) The discharge air from the cell stack 1 passes along the vapor-liquid-separation machine 34 by the gestalt of these above operations, and air and excessive moisture are discharged through an exhaust pipe 9 with it outside. With a pump 30, it is led to the steam generator 5, the liquid, i.e., the water, separated in the vapor-liquid-separation machine 34, it serves as a steam, and is used for humidification of reactant gas. The amount of humidification at this time is controlled by the same control as the 4th above-mentioned example.
[0072] (Effectiveness) Since according to the gestalt of these above operations humidification water is beforehand heated by the waste heat of a cell while the same operation effectiveness as the gestalt of the 1st operation is acquired, energy required for the heating heater in the steam generator 5 etc. is reducible. Therefore, the generating efficiency of a system can be raised further.
[0073] Furthermore, since the amount of the generation water of a fuel cell is sufficient for humidification water enough, from the exterior, it is not necessary to supply water, a simpler system configuration becomes possible, and miniaturization and lightweight-ization can be realized.

[0074] (9) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 15 publication of the 9th operation according to drawing 12 . Although the basic configuration of the gestalt of this operation is the same as that of the gestalt of the 1st operation, the points which are the systems which consist of two or more cell stacks differ. That is, the tees 37, 38, and 39 from a fuel feeding pipe 2, the air supply tubing 3, and the cooling water supply pipe 4 are connected to the extended cell stack 35. The entries 6 and 7 of a steam are established in the upstream of tees 37 and 38. Moreover, the air exhaust pipe 300 from the cell stack 35, the fuel gas exhaust pipe 301, and the cooling water exhaust pipe 302 are connected to the fuel gas exhaust pipe 9 from the cell stack 35, the air exhaust pipe 10, and the cooling water exhaust pipe 11.
[0075] (Operation) Since the entries 6 and 7 of a steam are established in the upstream of tees 37 and 38, humidification of two or more cell stacks 1 and 35 with one humidifier can be provided with the gestalt of these above operations. And like the gestalt of the 1st operation, a control unit 12 acts as the monitor of the output voltage of the cell stack 1 detected by the voltage sensor 19, judges the operating state of a cell, and determines the amount of humidification as the electric resistance value of the solid-state polyelectrolyte film detected by the resistance sensor 18 of the cell stack 1. A control unit 12 will order it the required amount of humidification to the steam generator 5, and reactant gas will be humidified according to this.
[0076] (Effectiveness) Since according to the gestalt of these above operations it is not necessary to establish a humidification means for every cell stack even if it is the fuel cell which has two or more cell stacks 1 and 35, large miniaturization is attained. Moreover, components mark also decrease sharply and a manufacturing cost can also be reduced greatly.
[0077] (10) Explain the gestalt of the operation corresponding to invention of gestalt (configuration) claim 16 publication of the 10th operation below according to drawing 13 . Although the basic configuration of the gestalt of this operation is the same as that of the gestalt of the 1st operation, after carrying out the preheating of the reactant gas through the inside of the cell stack 1, the points which he is trying to humidify differ. That is, the fuel gas supply pipe 2 and the air supply tubing 3 have penetrated the preheating ducts 40 and 41 prepared in the cell stack 1. And the entries 6 and 7 of a steam are established in the fuel gas supply pipe 2 and the air supply tubing 3 which came out of the preheating ducts 40 and 41, and it is further led in the cell stack 1.
[0078] (Operation) With the gestalt of these above operations, the preheating of the fuel gas supplied from the fuel gas supply pipe 2 and the air supply tubing 3 and the air is carried out through the preheating ducts 40 and 41 prepared in the cell stack 1. And after being humidified by the steam generator 5 in the exterior of the cell stack 1, it is led in the cell stack 1 and reacts.
[0079] (Effectiveness) Since according to the gestalt of these above operations the preheating of the reactant gas is carried out and a steam is supplied in the condition that temperature is high, it is hard coming to condense the steam which blew off in reactant gas, and the effective humidification of it is attained in a wide range temperature field. Moreover, since the heat produced by generation of

electrical energy of the cell stack 1 is used for the preheating of reactant gas, it is efficient.
[0080] (11) Gestalt this invention of other operations is not limited to the gestalt of the above operations, and the configuration of each part material can be changed suitably. For example, as a gestalt of the operation corresponding to invention according to claim 4, instead of the humidity sensors 13 and 14 in the gestalt of the 2nd operation, even if it uses the current sensor which measures the current of the cell stack 1, it can consider as the information for the amount decision of humidification. That is, since the amount of humidification is proportional to a burden mostly, if it sets up a proportionality constant beforehand, it can compute the amount of humidification required in order to consider as the optimal humidity.
[0081] Furthermore, on a system, since a burden is determined from the side to be used in many cases, in that case, the control unit 12 will grasp the burden, and even if it is the case where a sensor is not used, a certain amount of control is attained.
[0082] Moreover, as a gestalt of the operation corresponding to claim 5 and invention according to claim 6, even if it uses the flow rate sensor of fuel gas instead of a humidity sensor, it can consider as the information for the amount decision of humidification. That is, since the amount of humidification is proportional to a fuel flow mostly, if it sets up a proportionality constant beforehand, it can compute the amount of humidification required in order to consider as the optimal humidity. The same thing can completely be said also about an air flow rate.
[0083] Furthermore, since a burden is determined on a system from the side to be used in many cases and a burden is proportional to the amount of reactant gas mostly again, even if it is the case where the control unit 12 will grasp the amount of reactant gas, and does not use a sensor in that case, a certain amount of control is possible.
[0084] Moreover, it is also possible as a gestalt of the operation corresponding to invention according to claim 8 to form the steam generator 5 instead of the booster pump 20 in the gestalt of the 3rd operation of the above. Moreover, although humidification by the side of fuel gas is performed with the gestalt of the 3-6th operations of the above, it is also possible to perform humidification by the side of air by the same approach. Moreover, although acted as the monitor of the condition of the typical cell stack 1 as an operating state of a cell with the gestalt of the 9th operation of the above, two or more cell stacks 1 and the value of an average of 35 may be adopted. Moreover, a humidity sensor which stated the humidification condition with the gestalt of the 2nd operation as a means which acts as a monitor may be used, and a flow rate sensor may be used. Furthermore, various humidification means which it is not limited to the steam generator shown in drawing 12 as a humidification means, and were stated with the gestalt of the 3-6th operations are applicable.
[0085] Moreover, with the gestalt of the 10th operation, since evaporation of water is further promoted also when the atomized water which was shown in the gestalt of the 3-6th operations is used, more positive humidification is attained so that

water may not condense around. As a preheating means, the heat exchanger of cooling water and reactant gas may be used.

[0086]

[Effect of the Invention] As explained above, even if according to this invention it gives moderate moisture to the solid-state polyelectrolyte film and actuation conditions, such as load conditions, change to it, the solid-state polyelectrolyte mold fuel cell system which can control the amount of humidification to reactant gas can be offered so that it can operate in the condition optimal as a fuel cell. Moreover, the solid-state polyelectrolyte mold fuel cell system in which a miniaturization, lightweight-izing, and low-cost-izing are possible can be offered.

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[Translation done.]

## TECHNICAL FIELD

[Field of the Invention] This invention relates to the solid-state polyelectrolyte mold fuel cell system which used the solid-state poly membrane as an electrolyte, and relates to the maintenance function of the humidification condition of a solid-state poly membrane, and the solid-state polyelectrolyte mold fuel cell system which improved to space efficiency.

[Translation done.]

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## PRIOR ART

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[Description of the Prior Art] By making fuels, such as hydrogen, and oxidizers, such as air, react electrochemically, a fuel cell is equipment which transforms into direct electrical energy the chemical energy which a fuel has. Also in it, the solid-state polyelectrolyte mold fuel cell which used macromolecule ion exchange membrane for the electrolyte has the descriptions, like that power density is high, that structure is simple, and operating temperature is comparatively low, and the expectation for much more ED is growing.
[0003] The basic configuration of the cell in such a solid-state polyelectrolyte mold fuel cell is explained below according to drawing 14 . That is, the solid-state poly membrane 102 which has ion conductivity is inserted, the anode electrode 103 and the cathode electrode 104 are arranged, and the cell 101 is constituted. The anode electrode 103 is formed of anode catalyst bed 103a and anode porosity carbon plate 103b. The cathode electrode 104 is formed of cathode catalyst bed 104a and cathode porosity carbon plate 104b.
[0004] The separator 105 of gas impermeability which has conductivity is arranged at the upper and lower sides of this cell 101. The slots 103c and 104c for supplying reactant gas to the anode electrode 103 and the cathode electrode 104 are established in this separator 105.
[0005] In the above solid-state polyelectrolyte mold fuel cells, if fuel gas is supplied to the anode electrode 103 and oxidant gas is supplied to the cathode electrode 104, respectively, electromotive force will arise as follows according to electrochemical reaction in inter-electrode [ of the pair of a cell 101 ]. That is, first, although hydrogen is used as fuel gas and air is usually used as oxidant gas, if hydrogen is supplied to the anode electrode 103 and air is supplied to the cathode electrode 104, respectively, with the anode electrode 103, the supplied hydrogen will be dissociated into a hydrogen ion and an electron in anode catalyst bed 103a. And a hydrogen ion passes along the solid-state poly membrane 102, and an electron passes along an external circuit and moves to the cathode electrode 104, respectively.
[0006] On the other hand in the cathode electrode 104, the oxygen, the above-mentioned hydrogen ion, and electron in the supplied air react in cathode catalyst bed 104a, and water is generated. At this time, the electron passing through an external circuit serves as a current, and can supply power. That is, in the anode electrode 103 and the cathode electrode 104, the reaction shown in the following

formulas 1 and a formula 2, respectively advances. In addition, the generated water is discharged out of a cell with a unconverted gas.
[0007]
[Formula 1]
anode reaction: -- H2 ->2H++2e- the -- type 1 -- [Formula 2]
Cathode reaction: 2H++1/2O2+2e-->H2 O In the -- type 2 and time, since the electromotive force of a cell 101 is as low as less than [ 1V ], the usual practical use mold fuel cell system has the cell stack which carried out the laminating of the cell 101 of dozens - 100 numbers through the above-mentioned separator 105, and the generation of electrical energy by this cell stack is performed. And although the temperature up of such a cell stack will be carried out with a generation of electrical energy, in order to control this temperature up, the cooling plate is inserted for every cell of several sheets.
[0008] As a solid-state poly membrane 102 which has the ion conductivity used for the above solid-state polyelectrolyte mold fuel cells, the perfluoro ROKABON sulfonic acid (Nafion R : U.S., Du Pont) which is the proton exchange film is known, for example. While this film functions as an ion conductivity electrolyte by having and carrying out the saturation water of the exchange group of a hydrogen ion into a molecule, it also has the function to separate a fuel and an oxidizer. On the contrary, if membranous moisture content decreases, ion resistance will become high, the crossover which an oxidizing agent mixes with a fuel occurs, and a generation of electrical energy by the cell becomes impossible. For this reason, as for a solid-state poly membrane, what is considered as saturation water is desirable.
[0009] When the hydrogen ion separated with the anode electrode by generation of electrical energy moves to a cathode electrode through a solid-state poly membrane, in order that water may also move together on the other hand, in an anode electrode side, it is tended to dry a solid-state poly membrane. If there are few steams with which the fuel to supply or air is included, it is tended near [ each ] a reactant gas entry moreover, to dry a solid-state poly membrane. Generally from the above-mentioned reason, supplying the fuel humidified beforehand and an oxidizer is performed to the solid-state polyelectrolyte mold fuel cell.
[0010] As this humidification approach, various attempts are made from the former. The fuel cell shown in U.S. Pat. No. 5,284,718 is one of those are most generally known. This establishes a humidification field in the interior of a cell stack, as shown in <u>drawing 15</u> . That is, fuel gas and oxidant gas are humidified in a humidification field with a humidifier, before going into the reaction field which is the cell section. This humidification approach makes reactant gas adjoin water through semipermeable membrane, and when a water molecule passes semipermeable membrane, it humidifies. The amount of humidification is influenced by the differential pressure of water and reactant gas, temperature, the physical-properties value of a semipermeable membrane proper, area, thickness, and number of sheets.
[0011] Moreover, the humidification approach proposed in JP,7-29591,A as other conventional techniques is learned. As it is generally called the bubbler method and

is shown in drawing 16 , this installs water tank T equipped with the heater in fuel Rhine, and humidifies by passing fuel gas in water. The amount of humidification is influenced by the amount of fuel gas, the temperature of the water in a tank, and the geometry of a tank.

[0012] Furthermore, the thing using the ultrasonic vibrator proposed in JP,6-231788,A as other conventional techniques is known. As shown in drawing 17 , this approach installs the ultrasonic vibrator S connected to the power unit P in the interior of the tank T of water, humidifies the reactant gas which is atomizing the water by the supersonic wave and entered from reactant gas entry I, and discharges it from the reactant gas outlet O. The amount of humidification is influenced by the output of an ultrasonic vibrator S.

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[Translation done.]

## EFFECT OF THE INVENTION

(Effectiveness) Since fuel gas and the amount of humidification of air are controlled according to the gestalt of these above operations, acting as the monitor of the operating state of the cell stack 1 continuously, even if actuation conditions change, to compensate for this change, the solid-state polyelectrolyte film can be damp, a condition can be made good, and the always optimal operational status can be maintained.
[0052] Moreover, since it is not necessary to prepare a humidification part in the cell stack 1 like the above-mentioned conventional technique, the miniaturization of the cell stack 1 and lightweight-ization are attained. Furthermore, since there is the rate of flow quick enough in the oxidant gas in the fuel gas in a fuel feeding pipe 2, and the air supply tubing 3 and the rate of mixing with the steam supplied becomes quick, the need of a big humidifier, the big bubbler, etc. is not carried out, but system-wide miniaturization and lightweight-ization can be realized.
[0053] (2) Explain the gestalt of the operation corresponding to gestalt (configuration) claim 1 of the 2nd operation, claim 2, and invention according to claim 7 below according to drawing 3 . That is, humidity sensors 13 and 14 are formed in the downstream of the entries 6 and 7 of the steam with which the gestalt of this operation was prepared in a fuel feeding pipe 2 and the air supply tubing 3, respectively. And humidity sensors 13 and 14 are connected to the control unit 12. Thus, the configuration except having formed humidity sensors 13 and 14 instead of the resistance sensor 18 and the voltage sensor 19 is the same as that of the gestalt of the 1st operation of the above.

[Translation done.]

## TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, there were the following troubles in the above conventional solid-state polyelectrolyte mold fuel cell systems.
[0014] (1) By the method with the humidifier using the trouble semipermeable membrane by the humidifier method using semipermeable membrane, since it is necessary to build a humidifier into the interior of a cell stack, the whole cell stack becomes large and weight-izes.
[0015] Moreover, in order to make a humidification condition the optimal, it is necessary to control the amount of humidification according to an operation situation. However, by the method humidified in a humidification field before putting fuel gas and oxidant gas into a reaction field, control of the amount of humidification becomes very difficult. It is because it is impossible practically to be able to change neither temperature nor the reagent-gas-pressure force a lot, and to change the area and the number of sheets of the reaction film when some load conditions are set up.
[0016] Therefore, in this method, it becomes impossible [ the amount of humidification ] for designing with allowances so that relative humidity may always become 100%, and passing gas with low relative humidity somewhat according to an operation situation. Moreover, with this method, they are a lifting and a cone about the cell performance degradation there are too many amounts of humidification and according to the flooding of a cell contact layer.
[0017] (2) In the humidification method by the trouble bubbler by the bubbler method, since there is no humidification section in a cell stack, there is no problem of enlargement of a cell stack or weight-izing. However, since still bigger water tank T is needed as a humidifier, it enlarges and the whole system weight-izes. Moreover, since the electrical and electric equipment generated by the cell will be used when using electric heater H as a heat source, there is a problem of dropping the effectiveness of a system. Moreover, in order to use the heat generated in reaction time by the cell as a heat source, a big heat exchanger is needed.
[0018] Furthermore, although control of the amount of humidification cannot but correspond by changing the temperature of the water in water tank T in some decided load conditions, good responsibility cannot expect it easily from the amount of the water in water tank T being large, and the heat capacity of the water tank T itself being large. Moreover, since the temperature of reactant gas is

decided by temperature of a bubbler in the case of this method, it is freely uncontrollable.

[0019] (3) A degree of freedom is [ method / by the trouble supersonic wave by the ultrasonic sensing method / humidification / a bubbler method ] comparatively large, and since the amount of humidification is controllable with the output of an ultrasonic vibrator, as for the temperature of reactant gas, it is possible to make it change independently. However, to water tank T being required, it is unchanging, and a problem is in points, such as system-wide enlargement and weight-izing. Moreover, a response becomes slow, although it is not a bubbler method since a cell will be supplied after drawing reactant gas in water tank T specially and making it mix with waterdrop in order to carry the water atomized by the supersonic wave.

[0020] (4) Although three common conventional examples of the trouble above are typical, the common fundamental concept of these methods is supplied to a cell, after introducing reactant gas in a humidifier and making it mix. However, since there is almost no flow in a steam side when it is made this method, the rate of mixing becomes slow. Therefore, in order to make the mixed state into sufficient thing, a big tooth space is needed.

[0021] This invention is proposed in order to solve the trouble of the above conventional techniques, and even if it gives moderate moisture to the solid-state polyelectrolyte film and actuation conditions, such as load conditions, change, the purpose is in offer the solid-state polyelectrolyte mold fuel cell system which can control the amount of humidification to reactant gas so that it can operate in the condition optimal as a fuel cell.

[0022] Moreover, other purposes of this invention are to offer the solid-state polyelectrolyte mold fuel cell system in which a miniaturization, lightweight-izing, and low-cost-izing are possible.

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[Translation done.]

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## MEANS

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[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention has the following technical features in the solid-state polyelectrolyte mold fuel cell system by which the electrolyte membrane which consists of a solid-state macromolecule was equipped with the cell stack which has at least one cell arranged between a fuel electrode and an oxidizer pole, the fuel feeding pipe which supplies fuel gas to said fuel electrode, and the oxidizer supply pipe which supplies oxidant gas to said oxidizer pole.
[0024] That is, invention according to claim 1 is characterized by establishing a humidification means to supply a steam or the atomized water to either [ at least ] said fuel feeding pipe or said oxidizer supply pipe. In the above invention according to claim 1, since the amount of humidification is controllable to arbitration with a humidification means, when [ which is the need ] only a complement humidifies reactant gas by the way, the good positive humidification of responsibility is attained and a cell stack can be maintained to the always optimal operational status. Furthermore, since there is the rate of flow quick enough in the oxidant gas and the steam in the fuel gas in a fuel feeding pipe, and an oxidizer supply pipe and the rate of mixing becomes quick, neither a big humidifier nor a big bubbler is needed, but a compact and lightweight system configuration becomes possible.
[0025] Invention according to claim 2 is characterized by having the control unit which performs feedback control to the amount of supply of the steam by said humidification means, or the atomized water based on the operating state of said cell stack in a solid-state polyelectrolyte mold fuel cell system according to claim 1. In the above invention according to claim 2, it can supervise in what kind of condition the cell is operating, humidification [ what ] can judge the need to reactant gas in the condition, it can be told to a humidification means, and required humidification can be performed. This becomes possible to maintain a fuel cell to the always optimal operational status.
[0026] Invention according to claim 3 is characterized by the operating states of said cell stack being the electric resistance value of said electrolyte membrane, and the output voltage of a cell in a solid-state polyelectrolyte mold fuel cell system according to claim 2. If an electric resistance value is low when the film is generally damp enough as a film property, and the film is further damp with the above invention according to claim 3 to the substrate layer on the catalyst bed which gets wet too much and approaches, or its outside, since the diffusion to the

film surface of reactant gas is checked, the so-called FURATTINGU phenomenon arises and the cell engine performance falls remarkably, a generation-of-electrical-energy electrical potential difference will fall remarkably. When it is judged as desiccation feeling and the amount of humidification is increased, when an electric resistance value increases, a membrane resistance value is low and output voltage has fallen from this film property, control which gets wet, judges it as **** and stops the amount of humidification is performed. Thus, if it controls, operation is continuable by making a cell into the always optimal humidification condition.

[0027] Invention according to claim 4 is characterized by the operating state of said cell stack being the burden of a cell stack in a solid-state polyelectrolyte mold fuel cell system according to claim 2. In the above invention according to claim 4, the burden of a cell, i.e., the generation-of-electrical-energy output of a cell, is in proportionality mostly with the amount of reactant gas. Moreover, the amount of reactant gas and the amount of humidification are also in proportionality mostly. Therefore, if a sensor detects the burden of a cell, the required amount of humidification can be determined easily. Moreover, since the control unit always grasps the required burden demanded from a use side when operating a system, even if it is the case where especially a sensor is not formed, practically sufficient control of it is attained.

[0028] Invention according to claim 5 is characterized by the operating state of said cell stack being a fuel gas flow rate which flows said fuel feeding pipe in a solid-state polyelectrolyte mold fuel cell system according to claim 2. In the above invention according to claim 5, if a fuel gas flow rate is measured directly, based on this, the amount of humidification of fuel gas can mainly be determined. Moreover, it becomes possible [ a flow rate ], since each other has a fuel flow and an oxidizer flow rate mostly at proportionality to determine the amount of humidification of oxidant gas based on a fuel gas flow rate. Furthermore, since the control unit always grasps, even if a required fuel gas flow rate does not form especially a sensor, practically sufficient control of it is attained.

[0029] In invention according to claim 6, the operating state of said cell stack is characterized by being the oxidant gas flow rate which flows said oxidizer supply pipe in a solid-state polyelectrolyte mold fuel cell system according to claim 2. In the above invention according to claim 6, if an air content is measured directly on an oxidant gas flow rate and a general target, based on this, the amount of humidification by the side of air can mainly be determined. moreover, a fuel gas flow rate and an oxidant gas flow rate are mutual -- since it is in proportionality mostly, it also becomes possible to determine the amount of humidification of both gas. Furthermore, since the control unit always grasps the required fuel gas flow rate, even if it does not form especially a sensor, practically sufficient control is attained.

[0030] In a solid-state polyelectrolyte mold fuel cell system according to claim 1, a humidity sensor is formed in the downstream of said humidification means, and invention according to claim 7 is characterized by having the control unit which performs feedback control to the amount of supply of the steam by said humidification means, or the amount of supply of the atomized water based on the humidity detected by said humidity sensor. In the above invention according to

claim 7, a humidity sensor is formed in the downstream of the supply means of a steam or the atomized water, with this humidity sensor, the humidity of reactant gas after being humidified is measured, it judges whether delivery and a control unit are humidity with proper it about it at a control unit, and that amount of supply is directed to the supply means of a steam or the atomized water. Thereby, reactant gas is humidified proper and it becomes possible to maintain a fuel cell to the always optimal operational status.

[0031] Invention according to claim 8 is characterized by constituting said humidification means by the nozzle which spouts the steam prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the steam generator formed in the upstream in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 8, the steam generated with the steam generator blows off from a nozzle to reactant gas, it is mixed and reactant gas is humidified. At this time, since mixed humidification is compulsorily carried out by the quick rate of flow, compared with the case of the humidification which makes diffusion a subject, a humidification means can be far used as a compact.

[0032] Invention according to claim 9 is characterized by constituting said humidification means with the spraying nozzle prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the pressurizer which pressurizes the water prepared in the upstream in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 9, the water pressurized by the booster pump is introduced into a spraying nozzle, and water is atomized. The atomized water is fully as small as dozens of microns, within reactant gas, it evaporates immediately, and it is mixed and the diameter of a drop humidifies it. At this time, since mixed humidification is compulsorily carried out by the quick rate of flow, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact.

[0033] Invention according to claim 10 is characterized by constituting said humidification means with the ultrasonic spraying nozzle prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and the pump which supplies the water prepared in the upstream in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 10, since the diameter of a drop is atomized by the ultrasonic vibrator to dozens of microns, within reactant gas, it evaporates immediately, and it is mixed and the water supplied to the ultrasonic spraying nozzle is humidified. Since mixed humidification is compulsorily carried out by the quick rate of flow inside reactant gas, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact.

[0034] Invention according to claim 11 is characterized by said humidification means being constituted by the nozzle which supplies water to a part for a part for the converging section prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, and said converging section in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 11, reactant gas is that the increase of the rate of flow and a pressure decline by part for a converging section, attracts water from a nozzle and

atomizes water by the big speed difference. Within reactant gas, the atomized water evaporates immediately, and it is mixed and it is humidified. Thus, since mixed humidification is compulsorily carried out by the quick rate of flow inside reactant gas, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact. Furthermore, since a pump etc. becomes unnecessary, much more miniaturization is attained.

[0035] Invention according to claim 12 is characterized by constituting said humidification means with the rotating disc prepared at least in one of said fuel feeding pipe and said oxidizer supply pipe, the nozzle which supplies water toward said rotating disc, and the pump which supplies water to the upstream of said nozzle in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-7. In the above invention according to claim 12, water is atomized using the exfoliation phenomenon of the water from the disk by the centrifugal force by rotating a rotating disc at high speed and supplying water to the disk. The atomized water evaporates immediately within surrounding reactant gas, and humidifies reactant gas. Since mixed humidification is compulsorily carried out by the quick rate of flow inside reactant gas, compared with the humidification which makes diffusion a subject, a humidification means can be far used as a compact.

[0036] Invention according to claim 13 is characterized by connecting the passage of the cooling water of said cell stack on the supply way of the water to said humidification means in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-12. In the above invention according to claim 13, since the cooling water currently circulated in order to cool a fuel cell is used as a source of humidification, while being cooled to reactant gas beyond the need like [ in the case of using the water introduced from the exterior as it is ] is prevented, it becomes unnecessary [ preheating equipment ]. Therefore, a simpler and compact system becomes possible.

[0037] Invention according to claim 14 is characterized by connecting to the supply way of the water to said humidification means the passage of the generation water produced by the reaction within said cell stack in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-12. In the above invention according to claim 14, since water is surely generated at the time of a generation of electrical energy, when a fuel cell uses this as a source of humidification, it becomes unnecessary to newly carry out additional supply of the water from the exterior, and a system is simplified further.

[0038] Invention according to claim 15 is characterized by equipping any 1 term of claims 1-14 with two or more said cell stacks in the solid-state polyelectrolyte mold fuel cell system of a publication. In the above invention according to claim 15, since it is not necessary to form a humidification means in each and can respond with one humidification means even if it has two or more cell stacks, it becomes possible to miniaturize a system more.

[0039] Invention according to claim 16 is characterized by establishing a preheating means to heat said fuel gas and said oxidant gas beforehand with the heat generated with a fuel cell in a solid-state polyelectrolyte mold fuel cell system given in any 1 term of claims 1-15. In the above invention according to claim 16, since the preheating of the reactant gas supplied to a cell stack is

carried out by the preheating means, the steam or the atomized water for humidification is not condensed within a supply pipe. Moreover, since it can respond to wide range cell operating-temperature conditions, effective humidification is attained.

[0040]

[Embodiment of the Invention] The gestalt of operation of this invention is explained below according to a drawing.

[0041] (1) Explain the gestalt of the operation corresponding to invention of one to gestalt (configuration) claim 3 publication of the 1st operation below according to drawing 1 and drawing 2 . That is, as shown in drawing 1 , the fuel feeding pipe 2 which supplies the hydrogen which is fuel gas, and the air supply tubing 3 which supplies the air which is oxidant gas are connected to the cell stack 1 of a solid-state polyelectrolyte mold fuel cell. Moreover, the cooling water supply pipe 4 is connected to the cell stack 1.

[0042] The steam generator 5 which supplies a steam is connected to these fuel feeding pipes 2 and air supply tubing 3. Here, 6 in drawing and 7 show the entry where a steam blows off in a fuel feeding pipe 2 and the air supply tubing 3, respectively. Flow control valves 16 and 17 are formed in the passage from the steam generator 5 to a fuel feeding pipe 2 and the air supply tubing 3, and it has the composition that the amount of humidification to a fuel feeding pipe 2 and the air supply tubing 3 is controllable, respectively.

[0043] And the water supply pipe 8 for supplying water is connected to the steam generator 5. There is also an approach which may form a pump depending on the flow and pressure requirement of the reactant gas of the downstream, and pressurizes water as a pressurization means using the pressure of the reactant gas upstream in this water supply pipe 8.

[0044] Moreover, the fuel gas which was not able to react within the cell stack 1, the fuel gas exhaust pipe 10 which discharges air and the air exhaust pipe 9, and the cooling water exhaust pipe 11 which discharges cooling water are connected to the cell stack 1.

[0045] Furthermore, it considers as the sensor which acts as the monitor of the operating state of a fuel cell, and the resistance sensor 18 which detects the electric resistance value of the solid-state polyelectrolyte film, and the voltage sensor 19 which detects the output voltage of a fuel cell are included in the cell stack 1. This resistance sensor 18 and voltage sensor 19 are connected to the control unit 12. A control unit 12 judges the operating state of a cell, and it is connected to the steam generator 5 so that a steam yield can be directed.

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[Translation done.]

## OPERATION

(Operation) The operation of the gestalt of these above operations is as follows. That is, to the cell stack 1, the hydrogen which is fuel gas is supplied from a fuel feeding pipe 2, and a generation of electrical energy is performed by supplying the air which is oxidant gas from the air supply tubing 3. And with the cooling water supplied from the cooling water supply pipe 4, the heat generated inside a cell is absorbed in the form of the sensible heat of water, and a cell is held at proper temperature. Furthermore, the fuel gas and air which were not able to react within the cell stack 1 are discharged through the fuel gas exhaust pipe 10 and the air exhaust pipe 9, respectively. Moreover, cooling water is discharged through the cooling water exhaust pipe 11.
[0047] In such a generation-of-electrical-energy process, in a fuel feeding pipe 2 and the air supply tubing 3, the steam from the steam generator 5 blows off from entries 6 and 7, and fuel gas and air are humidified. A control unit 12 judges the operating state of a cell, and controls the steam amount of supply from the steam generator 5.
[0048] When an electric resistance value is high, the solid-state polyelectrolyte film is more specifically in dryness, but since the solid-state polyelectrolyte film means that it is in the condition too much of getting wet with some flooding if an electric resistance value is low and output voltage is low, the film is damp and a condition can be known with an electric resistance value and an output voltage value. therefore, suitable, when a control unit 12 directs an yield to the steam generator 5 based on the electric resistance value detected by the resistance sensor 18, and the output voltage value detected by the voltage sensor 19 -- it gets wet and a condition is maintained.
[0049] An example of the control sequence by such control unit 12 is shown in drawing 2 . In addition, a membrane resistance value sets R and an electrical-potential-difference value to V, and sets each threshold to Rs and Vs. That is, it is if the membrane resistance value R from the resistance sensor 18 and the electrical-potential-difference value V from a voltage sensor 19 are inputted into a control unit 12 (step 201). When larger than a threshold Rs, the increment command in the amount of humidification is issued for R to (step 202) and the steam generator 5 (step 203).
[0050] And R is smaller than a threshold Rs, and when smaller than a threshold Vs, the amount reduction command of humidification is issued for the electrical-

potential-difference value V to (step 204) and the steam generator 5. R is smaller than a threshold Rs, when larger than a threshold Vs, the amount of humidification of a steam generator is maintained, and the electrical-potential-difference value V serves as input waiting of the membrane resistance value R and the electrical-potential-difference value V (step 206).

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[Translation done.]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the gestalt of operation of the 1st of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 2] It is a flow chart showing the basic sequence of the humidification control in the gestalt of operation of drawing 1 .
[Drawing 3] It is the block diagram showing the gestalt of operation of the 2nd of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 4] It is the block diagram showing the gestalt of operation of the 3rd of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 5] It is the sectional view showing the fuel gas supply pipe near [ in the gestalt of operation of drawing 4 ] the spraying nozzle.
[Drawing 6] It is the block diagram showing the gestalt of operation of the 4th of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 7] It is the sectional view showing the fuel gas supply pipe near [ in the gestalt of operation of drawing 6 ] the ultrasonic nozzle.
[Drawing 8] It is the sectional view showing the fuel gas supply pipe near [ in the gestalt of operation of the 5th of the solid-state polyelectrolyte mold fuel cell system of this invention ] the converging section.
[Drawing 9] It is the sectional view showing the fuel gas supply pipe near [ in the gestalt of operation of the 6th of the solid-state polyelectrolyte mold fuel cell system of this invention ] the rotation atomization equipment.
[Drawing 10] It is the block diagram showing the gestalt of operation of the 7th of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 11] It is the block diagram showing the gestalt of operation of the 8th of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 12] It is the block diagram showing the gestalt of operation of the 9th of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 13] It is the block diagram showing the gestalt of operation of the 10th of the solid-state polyelectrolyte mold fuel cell system of this invention.
[Drawing 14] It is a sectional view showing an example of the cell structure of the conventional fuel cell.
[Drawing 15] It is the side elevation showing an example of the conventional fuel cell system which has a humidification part in the interior of a cell stack.
[Drawing 16] It is the block diagram showing an example of the conventional fuel

cell system equipped with the bubbler as humidification equipment.
[Drawing 17] It is the sectional view showing an example of the conventional cell stack equipped with ultrasonic atomization equipment as humidification equipment.
[Description of Notations]
1 35 -- Cell stack
2 -- Fuel feeding pipe
3 -- Air supply tubing
4 -- Cooling water supply pipe
5 -- Steam generator
6 7 -- Steam entry
8 22 -- Water supply pipe
9,300 -- Air exhaust pipe
10,301 -- Fuel gas exhaust pipe
11,302 -- Cooling water exhaust pipe
12 -- Control unit
13 14 -- Humidity sensor
16, 17, 23, 32 -- Flow control valve
18 -- Resistance sensor
19 -- Voltage sensor
20 -- High pressure pumping
21 -- Spraying nozzle
24 -- Ultrasonic nozzle
25 -- Water exhaust nozzle
26 -- Converging section
27 -- Rotating disc
28 -- Motor
29 -- Atomization room
30 -- Circulating pump
31 -- Radiator
33 -- Cooling water return pipe
34 -- Vapor-liquid-separation machine
37, 38, 39 -- Tee
40 41 -- Preheating duct
101 -- Cell
102 -- Solid-state poly membrane
103 -- Anode electrode
103a -- Anode catalyst bed
103b -- Anode porosity carbon plate
103c -- Fuel-supply slot
104 -- Cathode electrode
104a -- Cathode catalyst bed
104b -- Cathode porosity carbon plate
104c -- Oxidizer supply slot
105 -- Separator

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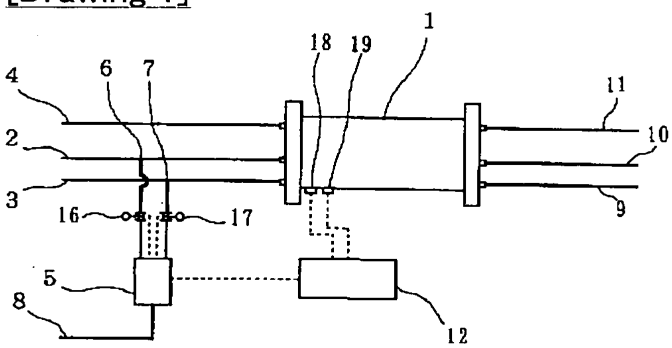
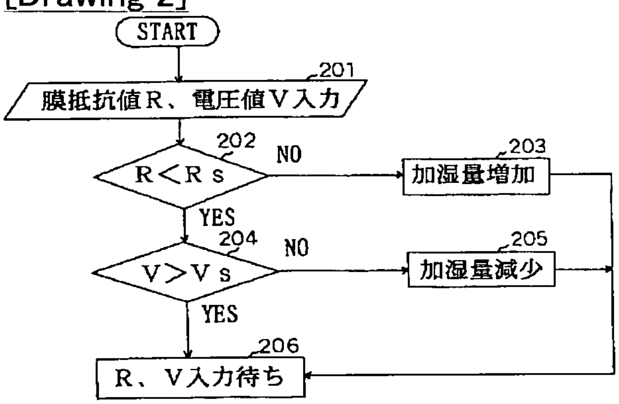
[Translation done.]

## DRAWINGS

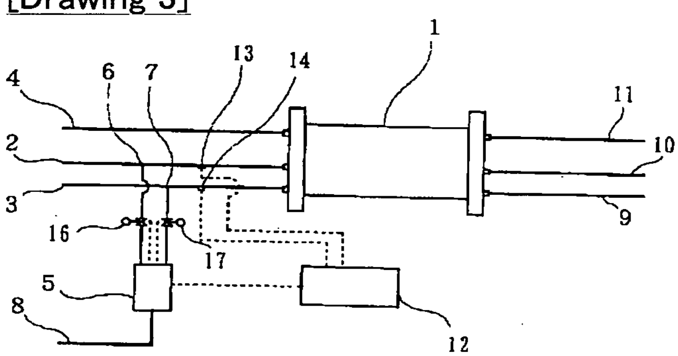
[Drawing 1]



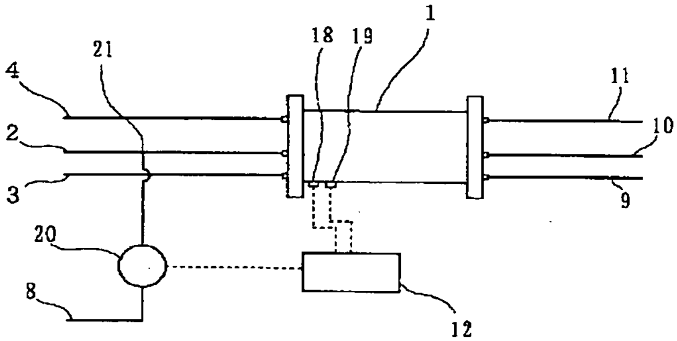

[Drawing 2]




[Drawing 3]




[Drawing 4]

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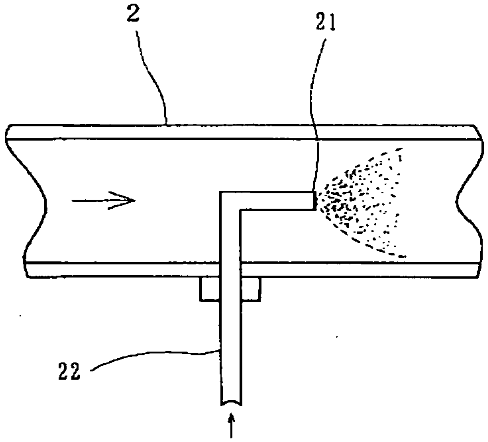


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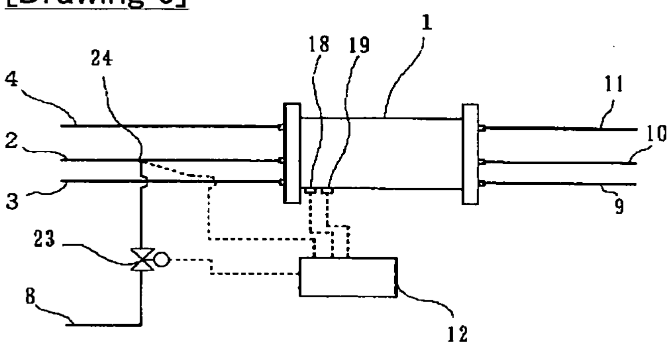


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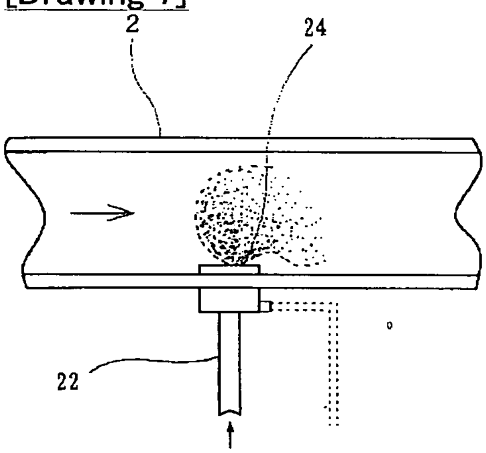
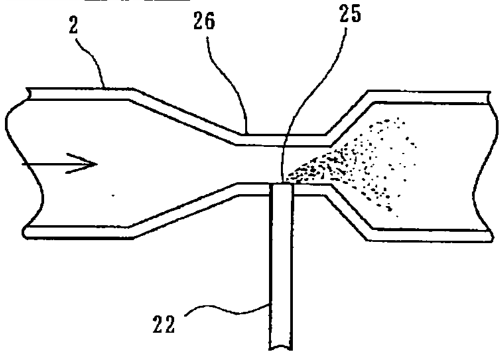
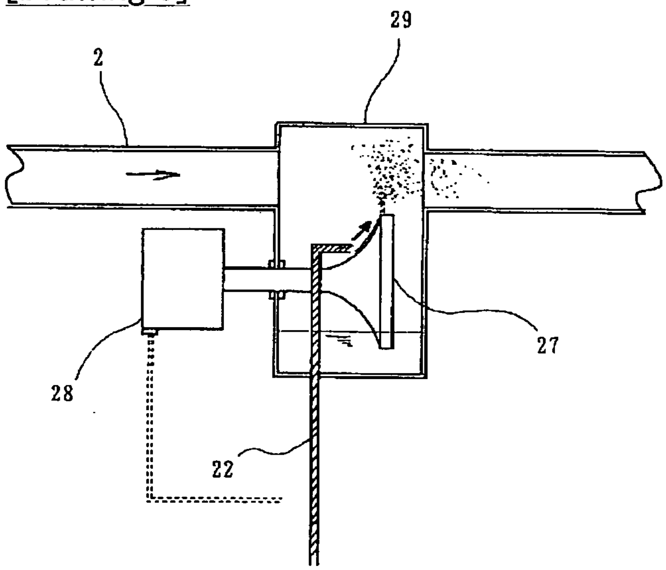


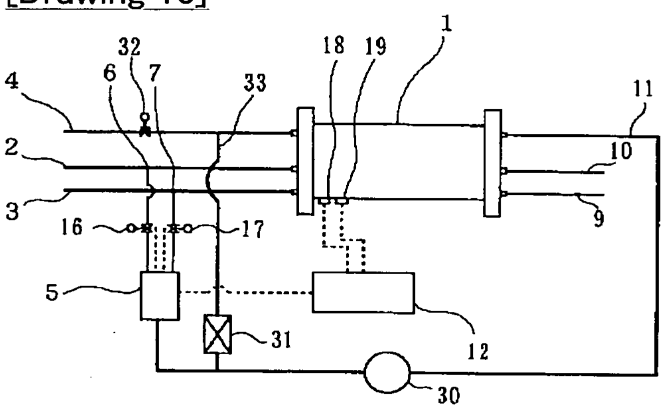
[Drawing 8]



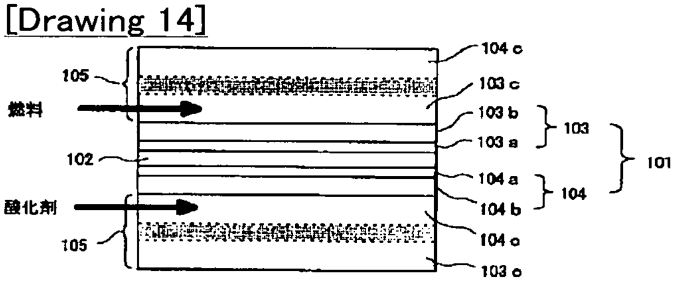

[Drawing 9]



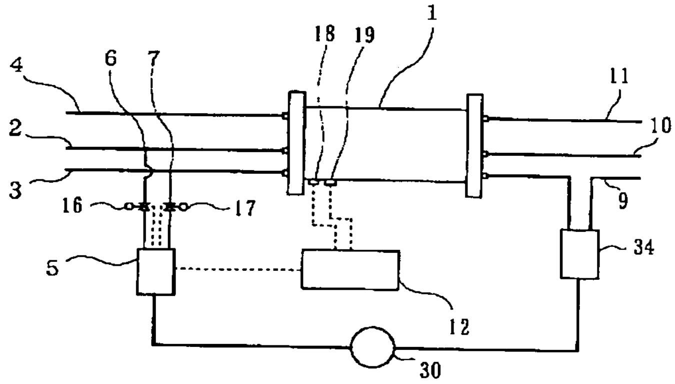

[Drawing 10]



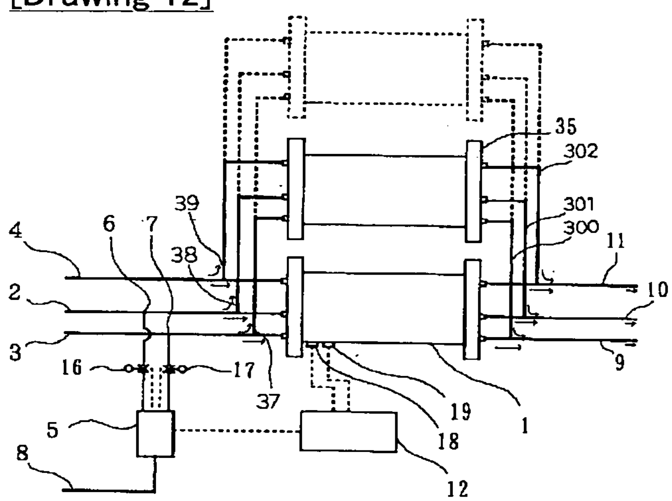

[Drawing 14]



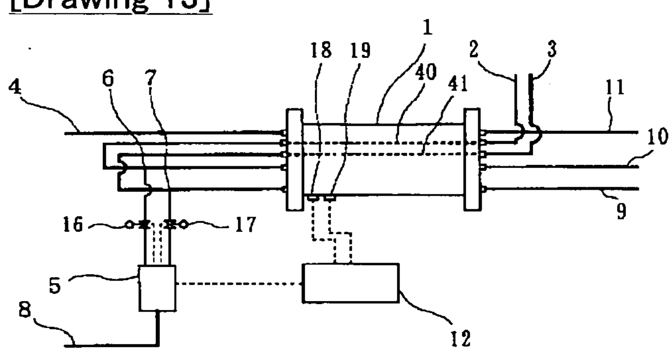
[Drawing 11]




[Drawing 12]




[Drawing 13]

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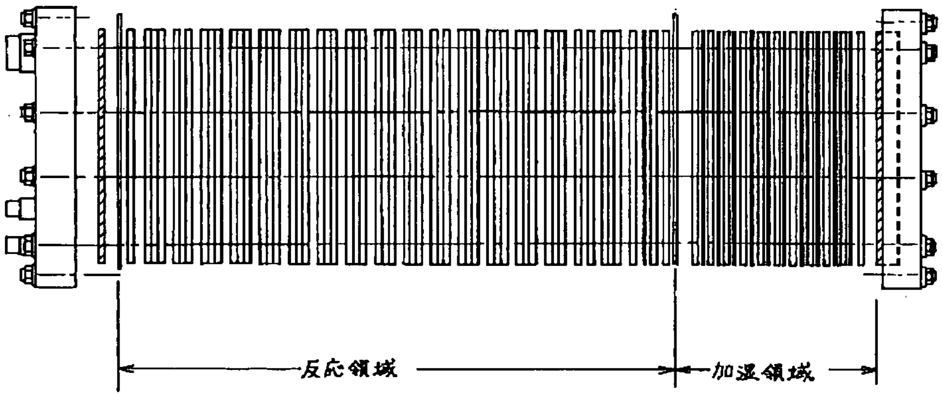
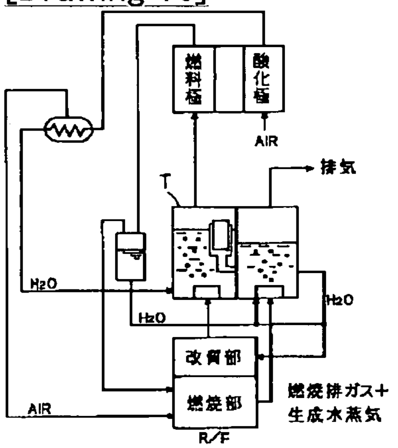
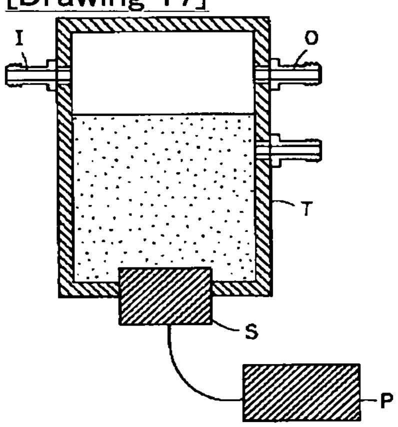



[Drawing 16]




[Drawing 17]

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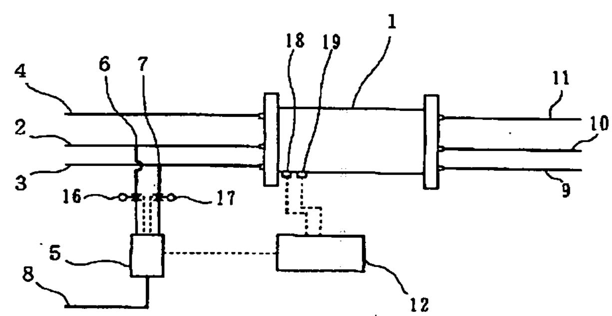
最終頁に続く

(54)【発明の名称】　固体高分子電解質型燃料電池システム

(57)【要約】

【課題】　負荷条件等作動条件が変化しても、燃料電池として最適な状態で動作できるように、反応ガスへの加湿量をコントロール可能な固体高分子電解質型燃料電池システムを提供する。

【解決手段】　固体高分子電解質型燃料電池の電池スタック１に燃料供給管２、空気供給管３、冷却水供給管４、燃料ガス排出管１０、空気排出管９、冷却水排出管１１を接続する。燃料供給管２と空気供給管３に水蒸気発生装置５を接続する。水蒸気発生装置５から燃料供給管２及び空気供給管３への流路に、流量制御弁１６，１７を設ける。水蒸気発生装置５に水供給管８を接続する。電池スタック１に、抵抗値センサー１８と電圧センサー１９を組み込む。抵抗値センサー１８と電圧センサー１９を、制御装置１２に接続する。制御装置１２を、水蒸気発生装置５に接続する。



【特許請求の範囲】
【請求項１】　固体高分子から成る電解質膜が燃料極と酸化剤極との間に配置された単電池を少なくとも一つ有する電池スタックと、前記燃料極に燃料ガスを供給する燃料供給管と、前記酸化剤極に酸化剤ガスを供給する酸化剤供給管とを備えた固体高分子電解質型燃料電池システムにおいて、
前記燃料供給管及び前記酸化剤供給管の少なくとも一方に、水蒸気若しくは微粒化された水を供給する加湿手段が設けられていることを特徴とする固体高分子電解質型燃料電池システム。
【請求項２】　前記電池スタックの作動状態に基づいて、前記加湿手段による水蒸気若しくは微粒化された水の供給量に対して、フィードバック制御を行う制御装置を備えたことを特徴とする請求項１記載の固体高分子電解質型燃料電池システム。
【請求項３】　前記電池スタックの作動状態は、前記電解質膜の電気抵抗値及び電池の出力電圧であることを特徴とする請求項２記載の固体高分子電解質型燃料電池システム。
【請求項４】　前記電池スタックの作動状態は、電池スタックの負荷量であることを特徴とする請求項２記載の固体高分子電解質型燃料電池システム。
【請求項５】　前記電池スタックの作動状態は、前記燃料供給管を流れる燃料ガス流量であることを特徴とする請求項２記載の固体高分子電解質型燃料電池システム。
【請求項６】　前記電池スタックの作動状態は、前記酸化剤供給管を流れる酸化剤ガス流量であることを特徴とする請求項２記載の固体高分子電解質型燃料電池システム。
【請求項７】　前記加湿手段の下流側に、湿度センサーが設けられ、
前記湿度センサーにより検知された湿度に基づいて、前記加湿手段による水蒸気の供給量若しくは微粒化された水の供給量に対して、フィードバック制御を行う制御装置を備えたことを特徴とする請求項１記載の固体高分子電解質型燃料電池システム。
【請求項８】　前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた水蒸気を噴出するノズルと、その上流側に設けられた水蒸気発生装置とによって構成されていることを特徴とする請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項９】　前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた噴霧ノズルと、その上流側に設けられた水を加圧する加圧装置とによって構成されていることを特徴とする請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１０】　前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた超音波噴霧ノズルと、その上流側に設けられた水を供給するポンプとによって構成されていることを特徴とする請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１１】　前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた絞り部分と、前記絞り部分に水を供給するノズルとによって構成されていることを特徴とする請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１２】　前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた回転円盤と、前記回転円盤に向かって水を供給するノズルと、前記ノズルの上流側に水を供給するポンプとによって構成されていることを特徴とする請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１３】　前記電池スタックの冷却水の流路が、前記加湿手段への水の供給路に接続されていることを特徴とする請求項１～１２のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１４】　前記電池スタック内で反応により生じた生成水の流路が、前記加湿手段への水の供給路に接続されていることを特徴とする請求項１～１２のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１５】　前記電池スタックを複数備えていることを特徴とする請求項１～１４のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【請求項１６】　前記燃料ガスと前記酸化剤ガスとを、燃料電池にて発生する熱により予熱する予熱手段が設けられていることを特徴とする請求項１～１５のいずれか１項に記載の固体高分子電解質型燃料電池システム。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、固体高分子膜を電解質として用いた固体高分子電解質型燃料電池システムに係り、固体高分子膜の加湿状態の保持機能と、スペース効率に改良を施した固体高分子電解質型燃料電池システムに関する。
【０００２】
【従来の技術】燃料電池は水素などの燃料と空気などの酸化剤を電気化学的に反応させることにより、燃料のもつ化学的エネルギーを直接電気エネルギーに変換する装置である。その中でも、電解質に高分子イオン交換膜を用いた固体高分子電解質型燃料電池は、出力密度が高いこと、構造が単純であること、動作温度が比較的低いことなどの特徴があり、より一層の技術開発への期待が高まっている。
【０００３】このような固体高分子電解質型燃料電池に

おける単電池の基本構成を、図１４に従って以下に説明する。すなわち、イオン導電性を有する固体高分子膜１０２を挟んで、アノード電極１０３、カソード電極１０４が配置され、単電池１０１が構成されている。アノード電極１０３は、アノード触媒層１０３ａとアノード多孔質カーボン平板１０３ｂとによって形成されている。カソード電極１０４は、カソード触媒層１０４ａとカソード多孔質カーボン平板１０４ｂとによって形成されている。

【０００４】この単電池１０１の上下には、導電性を有するガス不透過性のセパレータ１０５が配置されている。このセパレータ１０５には、アノード電極１０３及びカソード電極１０４に反応ガスを供給するための溝１０３ｃ，１０４ｃが設けられている。

【０００５】以上のような固体高分子電解質型燃料電池においては、アノード電極１０３に燃料ガスを、カソード電極１０４に酸化剤ガスをそれぞれ供給すると、単電池１０１の一対の電極間で電気化学反応により、以下のように起電力が生じる。すなわち、通常、燃料ガスとしては水素が使用され、酸化剤ガスとしては空気が使用されるが、まず、アノード電極１０３に水素、カソード電極１０４に空気をそれぞれ供給すると、アノード電極１０３では、供給された水素はアノード触媒層１０３ａにおいて水素イオンと電子に解離する。そして、水素イオンは固体高分子膜１０２を通り、電子は外部回路を通って、それぞれカソード電極１０４に移動する。

【０００６】一方、カソード電極１０４においては、供給された空気中の酸素と上記水素イオンと電子がカソード触媒層１０４ａにおいて反応して水を生成する。このとき、外部回路を通った電子は電流となり電力を供給することができる。つまり、アノード電極１０３とカソード電極１０４においては、それぞれ以下の式１、式２に示す反応が進行する。なお、生成された水は、未反応ガスと共に電池外に排出される。

【０００７】

【化１】

$$\text{アノード反応：} H_2 \rightarrow 2H^+ + 2e^- \quad \cdots\text{式1}$$

【化２】

$$\text{カソード反応：} 2H^+ + 1/2O_2 + 2e^- \rightarrow H_2O \quad \cdots\text{式2}$$

ところで、単電池１０１の起電力は、１Ｖ以下と低いため、通常の実用型燃料電池システムは、数十～数百枚の単電池１０１を、上記セパレータ１０５を介して積層した電池スタックを有し、この電池スタックによる発電を行っている。そして、このような電池スタックは発電に伴って昇温することになるが、かかる昇温を制御するため冷却板が数枚の電池毎に挿入されている。

【０００８】以上のような固体高分子電解質型燃料電池に使用されるイオン導電性を有する固体高分子膜１０２としては、例えば、プロトン交換膜であるパーフルオロロカーボンスルホン酸（ナフィオン$^R$：米国、デュポン社）が知られている。この膜は、分子中に水素イオンの交換基を持ち、飽和含水することによりイオン導電性電解質として機能すると共に、燃料と酸化剤を分離する機能も有する。逆に、膜の含水量が少なくなるとイオン抵抗が高くなり、燃料と酸化剤が混合するクロスオーバが発生し、電池での発電が不可能となる。このため、固体高分子膜は飽和含水としておくことが望ましい。

【０００９】一方、発電によりアノード電極で分離した水素イオンが固体高分子膜を通りカソード電極に移動する時に、水も一緒に移動するため、アノード電極側では固体高分子膜は乾燥する傾向にある。また、供給する燃料又は空気の含まれる水蒸気が少ないと、それぞれの反応ガス入り口付近で固体高分子膜は乾燥する傾向にある。上記の理由から、固体高分子電解質型燃料電池には、予め加湿した燃料と酸化剤を供給することが一般的に行われている。

【００１０】この加湿方法としては、従来から様々な試みがなされている。最も一般的に知られているものとしては、米国特許ＵＳ－５，２８４，７１８に示されている燃料電池がある。これは、図１５に示すように、電池スタック内部に加湿領域を設けたものである。すなわち、燃料ガスと酸化剤ガスは、電池部である反応領域に入る前に、加湿器による加湿領域において加湿される。この加湿方法は、水と反応ガスを半透膜を介して隣接させ、水分子が半透膜を通過することにより加湿を行うものである。加湿量は、水と反応ガスの圧力差、温度、半透膜固有の物性値、面積、厚み、枚数によって左右される。

【００１１】また、他の従来技術として、特開平７－２９５９１において提案されている加湿方法が知られている。これは、一般にバブラー方式と呼ばれているものであって、図１６に示すように、燃料ラインにヒータを備えた水タンクＴを設置し、水の中に燃料ガスを通過させることにより加湿を行うものである。加湿量は燃料ガス量とタンク内の水の温度とタンクの幾何学的形状に左右される。

【００１２】さらに、他の従来技術として、特開平６－２３１７８８において提案されている超音波振動子を用いたものが知られている。この方法は、図１７に示すように、水のタンクＴの内部に、パワーユニットＰに接続された超音波振動子Ｓを設置し、超音波による水の霧化を行うことで、反応ガス入り口Ｉから入った反応ガスを加湿し、反応ガス出口Ｏから排出するものである。加湿量は超音波振動子Ｓの出力に左右される。

【００１３】

【発明が解決しようとする課題】しかしながら、以上のような従来の固体高分子電解質型燃料電池システムには

次のような問題点があった。
【００１４】（１）半透膜を用いた加湿器方式による問題点
半透膜を用いた加湿器による方式では、電池スタック内部に加湿器を組み込む必要があるために、電池スタック全体が大きくなり重量化する。
【００１５】また、加湿状態を最適なものとするためには、加湿量を運転状況に応じてコントロールする必要がある。しかし、燃料ガスと酸化剤ガスを反応領域に入れる前に加湿領域において加湿する方式では、加湿量のコントロールが非常に難しくなる。なぜなら、ある負荷条件が設定された場合には、温度や反応ガス圧力を大きく変化させることはできず、反応膜の面積や枚数を変化させることは、実用上不可能だからである。
【００１６】従って、この方式においては、加湿量は常時相対湿度が１００％となるように、余裕を持って設計することになり、運転状況に合わせて多少相対湿度が低いガスを流すことは不可能となる。また、かかる方式では、加湿量が多過ぎて、電池接触層のフラッディングによる電池性能の低下を起こしやすい。
【００１７】（２）バブラー方式による問題点
バブラーによる加湿方式では、電池スタックには加湿部がないため、電池スタックの大型化や重量化の問題はない。しかし、加湿器としては、さらに大きな水タンクＴが必要になるので、システム全体が大型化、重量化する。また、熱源として電気ヒータＨを用いる場合には、電池で発電した電気を使用することになるので、システムの効率を落とすという問題がある。また、熱源として電池で反応時に発生する熱を利用するには、大きな熱交換器が必要となる。
【００１８】さらに、加湿量のコントロールは、ある決められた負荷条件においては水タンクＴ内の水の温度を変えることで対応せざるを得ないが、水タンクＴ内の水の量が大きく、水タンクＴ自体の熱容量も大きいことから、良好な応答性が期待し難い。また、この方式の場合には、反応ガスの温度はバブラーの温度によって決まるので、自由にコントロールすることができない。
【００１９】（３）超音波方式による問題点
超音波による加湿方式では、バブラー方式に比べて自由度が比較的大きく、加湿量は超音波振動子の出力でコントロールできるため、反応ガスの温度は独立して変化させることが可能である。しかし、水タンクＴが必要であることには変わりなく、システム全体の大型化、重量化といった点に問題がある。また、超音波により微粒化された水を運ぶために、わざわざ水タンクＴ内に反応ガスを導いて、水滴と混合させたのち電池へ供給することになるので、バブラー方式ほどではないが、応答が遅くなる。
【００２０】（４）共通の問題点
上記の３つの従来例は代表的なものであるが、これらの方式の共通の基本的な概念は、加湿器内に反応ガスを導入し、混合させた後、電池へと供給するものである。しかし、かかる方式にすると、水蒸気側にほとんど流れがないため、混合速度が遅くなる。従って、混合状態を十分なものとするためには、大きなスペースが必要となる。
【００２１】本発明は、上記のような従来技術の問題点を解決するために提案されたものであり、その目的は、固体高分子電解質膜に適度な水分を与え、負荷条件等作動条件が変化しても、燃料電池として最適な状態で動作できるように、反応ガスへの加湿量をコントロール可能な固体高分子電解質型燃料電池システムを提供することにある。
【００２２】また、本発明の他の目的は、小形化、軽量化及び低コスト化が可能な固体高分子電解質型燃料電池システムを提供することにある。
【００２３】
【課題を解決するための手段】上記の目的を達成するために、本発明は、固体高分子から成る電解質膜が燃料極と酸化剤極との間に配置された単電池を少なくとも一つ有する電池スタックと、前記燃料極に燃料ガスを供給する燃料供給管と、前記酸化剤極に酸化剤ガスを供給する酸化剤供給管とを備えた固体高分子電解質型燃料電池システムにおいて、以下のような技術的特徴を有する。
【００２４】すなわち、請求項１記載の発明は、前記燃料供給管及び前記酸化剤供給管の少なくとも一方に、水蒸気若しくは微粒化された水を供給する加湿手段が設けられていることを特徴とする。以上のような請求項１記載の発明では、加湿手段によって加湿量を任意にコントロールできるので、必要な時に必要な量だけ反応ガスを加湿することによって、応答性がよく確実な加湿が可能となり、電池スタックを常時最適な運転状態に維持することができる。さらに、燃料供給管内の燃料ガス、酸化剤供給管内の酸化剤ガス及び水蒸気には、十分に速い流速があり、混合速度が速くなるために、大きな加湿器や、大きなバブラーなどを必要とせず、コンパクトで軽量なシステム構成が可能となる。
【００２５】請求項２記載の発明は、請求項１記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタックの作動状態に基づいて、前記加湿手段による水蒸気若しくは微粒化された水の供給量に対して、フィードバック制御を行う制御装置を備えたことを特徴とする。以上のような請求項２記載の発明では、電池がどのような状態で運転しているのかを監視し、その状態で反応ガスにどの程度の加湿が必要かを判断し、それを加湿手段に伝え、必要な加湿を行うことができる。これにより、燃料電池を常時最適な運転状態に維持することが可能となる。
【００２６】請求項３記載の発明は、請求項２記載の固体高分子電解質型燃料電池システムにおいて、前記電池

スタックの作動状態は、前記電解質膜の電気抵抗値及び電池の出力電圧であることを特徴とする。以上のような請求項３記載の発明では、一般に、膜特性として、膜が十分濡れている場合には電気抵抗値が低く、さらに膜が濡れすぎて近接する触媒層やその外側にあるサブストレート層まで濡れてしまうと、反応ガスの膜面への拡散が阻害されていわゆるフラッティング現象が生じ、電池性能が著しく低下するので、発電電圧が著しく落ちることになる。かかる膜特性から、電気抵抗値が増加した場合には乾燥気味と判断して加湿量を増加し、膜抵抗値が低く出力電圧が落ちている場合には濡れ過ぎと判断して加湿量を抑える制御を行う。このように制御すれば、電池を常時最適な加湿状態として運転を継続することができる。

【００２７】請求項４記載の発明は、請求項２記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタックの作動状態は、電池スタックの負荷量であることを特徴とする。以上のような請求項４記載の発明では、電池の負荷量、つまり電池の発電出力は、反応ガス量とほぼ比例関係にある。また、反応ガス量と加湿量もほぼ比例関係にある。従って、電池の負荷量をセンサーによって検出すれば、必要な加湿量を容易に決定することができる。また、システムを動作させる上で、利用側から要求される必要な負荷量は、常時制御装置が把握しているので、特にセンサーを設けない場合であっても、実用上十分な制御が可能となる。

【００２８】請求項５記載の発明は、請求項２記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタックの作動状態は、前記燃料供給管を流れる燃料ガス流量であることを特徴とする。以上のような請求項５記載の発明では、燃料ガス流量を直接測定すれば、これに基づいて、主に燃料ガスの加湿量を決定することができる。また、燃料流量と酸化剤流量とは、お互いにほぼ比例関係にあるので、燃料ガス流量に基づいて、酸化剤ガスの加湿量を決定することが可能となる。さらに、必要な燃料ガス流量は、常時制御装置が把握しているので、特にセンサーを設けなくても、実用上十分な制御が可能となる。

【００２９】請求項６記載の発明では、請求項２記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタックの作動状態は、前記酸化剤供給管を流れる酸化剤ガス流量であることを特徴とする。以上のような請求項６記載の発明では、酸化剤ガス流量、一般的には空気量を直接測定すれば、これに基づいて、主に空気側の加湿量を決定することができる。また、燃料ガス流量と酸化剤ガス流量は、お互いほぼ比例関係にあるので、両方のガスの加湿量を決定することも可能となる。さらに、必要な燃料ガス流量は常時制御装置が把握しているので、特にセンサーを設けなくても、実用上十分な制御が可能となる。

【００３０】請求項７記載の発明は、請求項１記載の固体高分子電解質型燃料電池システムにおいて、前記加湿手段の下流側に、湿度センサーが設けられ、前記湿度センサーにより検知された湿度に基づいて、前記加湿手段による水蒸気の供給量若しくは微粒化された水の供給量に対して、フィードバック制御を行う制御装置を備えたことを特徴とする。以上のような請求項７記載の発明では、水蒸気または微粒化された水の供給手段の下流側に湿度センサーを設け、この湿度センサーによって、加湿された後の反応ガスの湿度を測定し、それを制御装置に送り、制御装置はそれが適正な湿度であるかどうかを判断し、水蒸気または微粒化された水の供給手段へその供給量を指示する。これにより反応ガスは適正に加湿され、燃料電池を常時最適な運転状態に維持することが可能となる。

【００３１】請求項８記載の発明は、請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた水蒸気を噴出するノズルと、その上流側に設けられた水蒸気発生装置とによって構成されていることを特徴とする。以上のような請求項８記載の発明では、水蒸気発生装置にて発生した水蒸気は、ノズルより反応ガスへと噴出され、混合されて反応ガスが加湿される。このとき、速い流速で強制的に混合加湿されるため、拡散を主体とする加湿の場合に比べて、加湿手段をはるかにコンパクトにすることができる。

【００３２】請求項９記載の発明は、請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた噴霧ノズルと、その上流側に設けられた水を加圧する加圧装置とによって構成されていることを特徴とする。以上のような請求項９記載の発明では、加圧ポンプによって加圧された水が噴霧ノズルに導入され、水が微粒化される。微粒化された水は、液滴径が数十ミクロンと十分に小さく、反応ガス内で直ちに蒸発し、混合され加湿する。このとき、速い流速で強制的に混合加湿されるため、拡散を主体とする加湿に比べて、加湿手段をはるかにコンパクトにすることができる。

【００３３】請求項１０記載の発明は、請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた超音波噴霧ノズルと、その上流側に設けられた水を供給するポンプとによって構成されていることを特徴とする。以上のような請求項１０記載の発明では、超音波噴霧ノズルに供給された水は超音波振動子により液滴径が数十ミクロンまで微粒化されるので、反応ガス内で直ちに蒸発し、混合され加湿する。反応ガス内部の速い流速で強制

的に混合加湿されるため、拡散を主体とする加湿に比べて、加湿手段をはるかにコンパクトにすることができる。

【００３４】請求項１１記載の発明は、請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた絞り部分と、前記絞り部分に水を供給するノズルとによって構成されていることを特徴とする。以上のような請求項１１記載の発明では、反応ガスは絞り部分で流速が増し、圧力が低下することで、水をノズルより吸引し、その大きな速度差により水を微粒化する。微粒化された水は反応ガス内で直ちに蒸発し、混合され加湿する。このように、反応ガス内部の速い流速で強制的に混合加湿されるため、拡散を主体とする加湿に比べて、加湿手段をはるかにコンパクトにすることができる。さらに、ポンプ等も不要となるため、より一層のコンパクト化が可能となる。

【００３５】請求項１２記載の発明は、請求項１～７のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記加湿手段は、前記燃料供給管内及び前記酸化剤供給管内の少なくとも一方に設けられた回転円盤と、前記回転円盤に向かって水を供給するノズルと、前記ノズルの上流側に水を供給するポンプとによって構成されていることを特徴とする。以上のような請求項１２記載の発明では、回転円盤を高速で回転させ、その円盤に水を供給することにより、遠心力による円盤からの水の剥離現象を利用して水を微粒化する。微粒化された水は周囲の反応ガス内で直ちに蒸発し、反応ガスを加湿する。反応ガス内部の速い流速で強制的に混合加湿されるため、拡散を主体とする加湿に比べて、加湿手段をはるかにコンパクトにすることができる。

【００３６】請求項１３記載の発明は、請求項１～１２のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタックの冷却水の流路が、前記加湿手段への水の供給路に接続されていることを特徴とする。以上のような請求項１３記載の発明では、燃料電池を冷却するために循環させている冷却水を加湿源として用いるので、外部より導入した水をそのまま用いる場合のように反応ガスまで必要以上に冷却されることが防止されるとともに、予熱装置が不要となる。従って、より単純でコンパクトなシステムが可能となる。

【００３７】請求項１４記載の発明は、請求項１～１２のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタック内で反応により生じた生成水の流路が、前記加湿手段への水の供給路に接続されていることを特徴とする。以上のような請求項１４記載の発明では、燃料電池は発電時に必ず水が生成されるので、これを加湿源として利用することにより、新たに外部から水を追加供給する必要がなくなり、より一層システムが簡素化される。

【００３８】請求項１５記載の発明は、請求項１～１４のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記電池スタックを複数備えていることを特徴とする。以上のような請求項１５記載の発明では、複数の電池スタックを有していても、それぞれに加湿手段を設ける必要がなく、一つの加湿手段で対応できるために、よりシステムをコンパクト化することが可能となる。

【００３９】請求項１６記載の発明は、請求項１～１５のいずれか１項に記載の固体高分子電解質型燃料電池システムにおいて、前記燃料ガスと前記酸化剤ガスとを、燃料電池にて発生する熱により予熱する予熱手段が設けられていることを特徴とする。以上のような請求項１６記載の発明では、電池スタックに供給される反応ガスが予熱手段によって予熱されるので、加湿用の水蒸気あるいは微粒化された水は供給管内で凝縮することがない。また、より広範囲な電池動作温度条件に対応することができるため、効果的な加湿が可能となる。

【００４０】

【発明の実施の形態】本発明の実施の形態を、図面に従って以下に説明する。

【００４１】（１）第１の実施の形態

（構成）請求項１～３記載の発明に対応する実施の形態を、図１及び図２に従って以下に説明する。すなわち、図１に示すように、固体高分子電解質型燃料電池の電池スタック１には、燃料ガスである水素を供給する燃料供給管２と、酸化剤ガスである空気を供給する空気供給管３が接続されている。また、電池スタック１には、冷却水供給管４が接続されている。

【００４２】これらの燃料供給管２と空気供給管３には、水蒸気を供給する水蒸気発生装置５が接続されている。ここで、図中の６，７は、それぞれ水蒸気が燃料供給管２と空気供給管３に噴出される入り口を示している。水蒸気発生装置５から燃料供給管２及び空気供給管３への流路には、流量制御弁１６，１７が設けられており、それぞれ燃料供給管２及び空気供給管３への加湿量をコントロールできる構成となっている。

【００４３】そして、水蒸気発生装置５には、水を供給するための水供給管８が接続されている。この水供給管８には、下流側の反応ガスの圧力条件によっては、ポンプを設ける場合もあり、加圧手段として、反応ガス上流側の圧力を利用して水を加圧する方法もある。

【００４４】また、電池スタック１には、電池スタック１内で反応しきれなかった燃料ガスと空気を排出する燃料ガス排出管１０及び空気排出管９と、冷却水を排出する冷却水排出管１１が接続されている。

【００４５】さらに、電池スタック１には、燃料電池の作動状態をモニターするセンサーとして、固体高分子電解質膜の電気抵抗値を検出する抵抗値センサー１８と、

燃料電池の出力電圧を検出する電圧センサー１９とが組み込まれている。この抵抗値センサー１８及び電圧センサー１９は、制御装置１２に接続されている。制御装置１２は、電池の作動状態を判断し、水蒸気発生量を指示できるように、水蒸気発生装置５に接続されている。

【００４６】（作用）以上のような本実施の形態の作用は以下の通りである。すなわち、電池スタック１に対して、燃料ガスである水素が燃料供給管２から供給され、酸化剤ガスである空気が空気供給管３から供給されることによって、発電が行われる。そして、冷却水供給管４から供給される冷却水によって、電池内部で発生する熱が、水の顕熱の形で吸収され、電池が適正な温度に保持される。さらに、電池スタック１内で反応しきれなかった燃料ガスと空気は、それぞれ燃料ガス排出管１０、空気排出管９を通って排出される。また、冷却水は冷却水排出管１１を通って排出される。

【００４７】このような発電過程において、燃料供給管２と空気供給管３には、水蒸気発生装置５からの水蒸気が入り口６，７から噴出され、燃料ガス及び空気が加湿される。制御装置１２は、電池の作動状態を判断し、水蒸気発生装置５からの水蒸気供給量を制御する。

【００４８】より具体的には、電気抵抗値が高いと固体高分子電解質膜が乾燥状態にあるが、電気抵抗値が低く、かつ出力電圧が低いと固体高分子電解質膜がフラッディング気味で濡れすぎの状態にあることを表しているので、膜の濡れ状態は、電気抵抗値と出力電圧値によって知ることができる。従って、抵抗値センサー１８によって検出された電気抵抗値と、電圧センサー１９によって検出された出力電圧値に基づいて、制御装置１２が水蒸気発生装置５に発生量を指示することにより、適切な濡れ状態が維持される。

【００４９】このような制御装置１２による制御シーケンスの一例を、図２に示す。なお、膜抵抗値はR、電圧値はVとし、それぞれのしきい値をRs，Vsとする。すなわち、制御装置１２に、抵抗値センサー１８からの膜抵抗値Rと電圧センサー１９からの電圧値Vが入力されると（ステップ２０１）。Rがしきい値Rsよりも大きい場合には（ステップ２０２）、水蒸気発生装置５に対して加湿量増加指令が出される（ステップ２０３）。

【００５０】そして、Rがしきい値Rsよりも小さく、電圧値Vがしきい値Vsよりも小さい場合には（ステップ２０４）、水蒸気発生装置５に対して加湿量減少指令が出される。Rがしきい値Rsよりも小さく、電圧値Vがしきい値Vsよりも大きい場合には、水蒸気発生装置の加湿量は維持され、膜抵抗値Rと電圧値Vの入力待ちとなる（ステップ２０６）。

【００５１】（効果）以上のような本実施の形態によれば、電池スタック１の作動状態を絶えずモニターしながら燃料ガス及び空気の加湿量をコントロールするので、作動条件が変化しても、この変化に合わせて固体高分子電解質膜の濡れ状態を良好なものとし、常に最適な運転状態を維持することができる。

【００５２】また、上記の従来技術のように電池スタック１内に加湿部分を設ける必要がないので、電池スタック１の小形化、軽量化が可能となる。さらに、燃料供給管２内の燃料ガス、空気供給管３内の酸化剤ガスには、十分に速い流速があり、供給される水蒸気との混合速度が速くなるので、大きな加湿器や大きなバブラーなどを必要せず、システム全体の小形化、軽量化が実現できる。

【００５３】（２）第２の実施の形態

（構成）請求項１、請求項２及び請求項７記載の発明に対応する実施の形態を、図３に従って以下に説明する。すなわち、本実施の形態は、燃料供給管２と空気供給管３に設けられた水蒸気の入り口６，７の下流側に、それぞれ湿度センサー１３，１４が設けられている。そして、湿度センサー１３，１４は、制御装置１２に接続されている。このように抵抗値センサー１８及び電圧センサー１９の代わりに湿度センサー１３，１４を設けた以外の構成は、上記の第１の実施の形態と同様である。

【００５４】（作用効果）以上のような本実施の形態では、電池スタック１が作動中、燃料ガスと空気が予め設定された湿度に維持できるよう、湿度センサー１３，１４によって測定される湿度をモニターしながら、制御装置１２によって水蒸気発生装置５及び流量制御弁１６，１７がコントロールされる。従って、第１の実施の形態と同様の作用効果が得られるとともに、燃料ガスと空気の湿度を直接測定するので、必要な加湿量をより正確にコントロールすることができる。

【００５５】（３）第３の実施の形態

（構成）請求項９記載の発明に対応する実施の形態を、図４及び図５に従って説明する。すなわち、本実施の形態においては、燃料供給管２の内部に、噴霧ノズル２１が設置されている。この噴霧ノズル２１は、水供給管２２を介して高圧ポンプ２０に接続され、高圧ポンプ２０は、外部から水を供給するための水供給管８に接続されている。そして、高圧ポンプ２０は、その回転数が制御装置１２によって制御可能に設けられている。このように水蒸気発生装置５、流量制御弁１６，１７の代わりに、噴霧ノズル２１及び高圧ポンプ２０を設けた以外の構成は、上記の第１の実施の形態と同様である。

【００５６】（作用）以上のような本実施の形態では、水供給管８から供給された水は、高圧ポンプ２０によって高圧となり、水供給管２２を介して噴霧ノズル２１に供給される。そして、図５に示すように、高圧水が微細孔を持つ噴霧ノズル２１を通過する際、直径数十ミクロン程度の小さな液滴に微粒化され、燃料供給管２内へ散布される。微粒化された液滴は燃料ガス内で予め蒸発し、燃料ガスを加湿する。このときの加湿量は、第１の実施の形態と同様に、制御装置１２において、燃料電池

の作動状態から必要な加湿量を判断し、それを高圧ポンプ２０の回転数へとフィードバックし、加湿量を増加したいときは回転数を上げ、低減したいときは回転数を下げる制御を行うことによってコントロールする。

【００５７】（効果）以上のような本実施の形態によれば、第１の実施の形態と同様な作用効果が得られるとともに、非常に単純な構造と小さな部材によって、加湿手段を構成することができるので、より一層コンパクトで軽量となる。

【００５８】（４）第４の実施の形態

（構成）請求項１０記載の発明に対応する実施の形態を、図６及び図７に従って説明する。すなわち、本実施の形態においては、燃料供給管内２内に、超音波ノズル２４が設けられている。この超音波ノズル２４には、流量制御バルブ２３が設けられた水供給管２２が接続されている。そして、水供給管２２は、外部から水を供給するための水供給管８に接続されている。超音波ノズル２４及び流量制御バルブ２３は、制御装置１２に接続されている。このように水蒸気発生装置５、流量制御弁１６，１７の代わりに、超音波ノズル２４及び流量制御バルブ２３を設けた以外の構成は、上記の第１の実施の形態と同様である。

【００５９】（作用）以上のような本実施の形態では、水供給管８から供給された水は、水供給管２２を介して超音波ノズル２４に供給される。超音波ノズル２４においては、超音波による霧化作用により、供給水が直径数十ミクロンまで微粒化され、燃料供給管２内へ散布されて、燃料ガスを加湿する。このときの加湿量は、第１の実施の形態と同様に、電池スタック１の作動状態から必要な加湿量を判断し、それを流量制御バルブ２３へとフィードバックすることにより制御される。つまり、加湿量を増加するときはバルブ開度を大きくし、低減したいときにはバルブ開度を小さくする制御を行うことによって、加湿量がコントロールされる。

【００６０】（効果）以上のような本実施の形態によれば、第１の実施の形態と同様の作用効果が得られるとともに、第３の実施の形態に示した高圧噴霧方式に比べて、高圧ポンプ２０が不要となるので、さらに簡潔な構成とすることができ、より一層のコンパクト化が実現できる。

【００６１】（５）第５の実施の形態

（構成）請求項１１記載の発明に対応する実施の形態を、図８に従って説明する。本実施の形態は、上記の第４の実施の形態とほぼ同様の構成であるが、燃料供給管２内には絞り部分２６が設けられ、この絞り部分２６に、超音波ノズル２４ではなく水噴霧孔２５が設けられている点が異なる。そして、この水噴霧孔２５には、水供給管２２が接続されている。

【００６２】（作用）以上のような本実施の形態では、高速噴流による水の吸引効果、つまり霧吹き効果によって、燃料ガスを加湿する。すなわち、燃料供給管２を通ってきた燃料は、絞り部分２６に近付くにつれて流速を徐々に増すが、反対に圧力は徐々に下がり、絞り部分２６において最低の圧力となる。すると、水供給管２２から供給される水が、水噴霧孔２５を通って吸引され、高速の燃料ガスによって微粒化されて、加湿される。このときの加湿量は、上記の第４の実施例と同様の制御でコントロールされる。

【００６３】（効果）以上のような本実施の形態によれば、第１の実施の形態と同様の作用効果が得られるとともに、第４の実施の形態に比べて、超音波ノズル２４が不要となるので、さらに構造を単純にすることができる。また、流量制御弁２３の制御以外には、水を霧化するための電力を必要としないので、より高い発電効率を得ることができる。

【００６４】（６）第６の実施の形態

（構成）請求項１２記載の発明に対応する実施の形態を、図９に従って説明する。本実施の形態は、上記の第４の実施の形態とほぼ同様の構成であるが、回転霧化方式を採用している点が異なる。すなわち、燃料供給管２内の一部には、霧化室２９が設けられており、その中に、モータ２８につながれた回転円盤２７が配置されている。この回転円盤２７には、テーパ部分が設けられ、テーパ部分に近接する位置に、水供給管２２の先端部が配設されている。

【００６５】（作用）以上のような本実施の形態では、モータ２８によって回転円盤２７が高速で回転する。そして、水供給管２２から供給される水は、回転円盤２７のテーパ部分によって、遠心力効果で回転円盤２７端部へと移動し、当該端部から液滴となって燃料供給管２の一部である霧化室２９へと散布される。散布された水は、下流側にいくに従って蒸発し、燃料ガスを加湿する。このときの加湿量は、上記の第４の実施例と同様の制御でコントロールされる。

【００６６】（効果）以上のような本実施の形態によれば、第１の実施の形態と同様の作用効果が得られるとともに、幅広い水の流量に応じて、常に一定の粒径の液滴を供給することができるので、極めて安定した加湿を実現できる。

【００６７】（７）第７の実施の形態

（構成）請求項１３記載の発明に対応する実施の形態を、図１０に従って説明する。本実施の形態は、第１の実施の形態とほぼ同様の構成であるが、加湿水として電池の冷却水を用いる点が異なる。すなわち、電池スタック１の冷却水排出管１１は、ポンプ３０を介してラジエータ３１に接続されている。このラジエータ３１は、戻り管３３を介して冷却水供給管４に接続されている。冷却水供給管４には、補給用バルブ３２が設けられている。また、冷却水排出管１１は、ポンプ３０を介して水蒸気発生器５にも接続されている。

【００６８】（作用）以上のような本実施の形態では、電池スタック１から排出された冷却水は、ポンプ３０によって送られてラジエータ３１に入り、設定温度まで冷却された後、戻り管３３を通って再度電池スタック１へ供給され、循環する。そして、循環水の一部は、水蒸気発生器５に導かれ、反応ガスの加湿に用いられる。このときの加湿量は、上記の第１の実施例と同様の制御でコントロールされる。冷却水量は加湿に用いられると徐々に減ってくるので、補給用バルブ３２を開き、足りない分を補給する。

【００６９】（効果）以上のような本実施の形態によれば、第１の実施の形態と同様の作用効果が得られるとともに、加湿水が予め電池の廃熱により加熱されるので、水蒸気発生器５における加熱ヒータ等に必要なエネルギーを節減できる。従って、システムの発電効率がより一層向上する。

【００７０】（８）第８の実施の形態

（構成）請求項１４記載の発明に対応する実施の形態を、図１１に従って説明する。本実施の形態は、上記の第７の実施の形態とほぼ同様の構成であるが、燃料電池内部で反応時に生成された生成水を加湿水として用いる点が異なる。すなわち、電池スタック１の空気排出管９には、気液分離器３４が設けられている。この気液分離器３４は、ポンプ３０を介して水蒸気発生器５に接続されている。

【００７１】（作用）以上のような本実施の形態では、電池スタック１からの排出空気は、気液分離器３４を通り、空気及び余分な水分が排出管９を通って外部へと排出される。気液分離器３４において分離された液体すなわち水は、ポンプ３０によって水蒸気発生器５に導かれ、水蒸気となって反応ガスの加湿に用いられる。このときの加湿量は、上記の第４の実施例と同様の制御でコントロールされる。

【００７２】（効果）以上のような本実施の形態によれば、第１の実施の形態と同様の作用効果が得られるとともに、加湿水が予め電池の廃熱により加熱されるので、水蒸気発生器５における加熱ヒータ等に必要なエネルギーを節減できる。従って、システムの発電効率を一層向上させることができる。

【００７３】さらに、加湿水は燃料電池の生成水の量で十分足りるので、外部より水を補給する必要がなく、より単純なシステム構成が可能となり、コンパクト化、軽量化が実現できる。

【００７４】（９）第９の実施の形態

（構成）請求項１５記載の発明に対応する実施の形態を、図１２に従って説明する。本実施の形態の基本構成は、第１の実施の形態と同様であるが、複数の電池スタックからなるシステムである点が異なる。すなわち、増設された電池スタック３５には、燃料供給管２、空気供給管３及び冷却水供給管４からの分岐部３７，３８，３９が接続されている。水蒸気の入り口６，７は、分岐部３７，３８の上流側に設けられている。また、電池スタック３５からの空気排出管３００、燃料ガス排出管３０１、冷却水排出管３０２は、電池スタック３５からの燃料ガス排出管９、空気排出管１０、冷却水排出管１１に接続されている。

【００７５】（作用）以上のような本実施の形態では、水蒸気の入り口６，７は、分岐部３７，３８の上流側に設けられているので、一つの加湿器で複数の電池スタック１，３５の加湿をまかなうことができる。そして、制御装置１２は、第１の実施の形態と同様に、電池スタック１の抵抗値センサー１８によって検出される固体高分子電解質膜の電気抵抗値と、電圧センサー１９によって検出される電池スタック１の出力電圧をモニターし、電池の作動状態を判断して加湿量を決定する。制御装置１２は水蒸気発生器５へ必要な加湿量を指令し、これに従って反応ガスが加湿されることになる。

【００７６】（効果）以上のような本実施の形態によれば、複数の電池スタック１，３５を有する燃料電池であっても、各電池スタックごとに加湿手段を設ける必要がないので、大幅なコンパクト化が可能となる。また、部品点数も大幅に少なくなり、製造コストも大きく低減できる。

【００７７】（１０）第１０の実施の形態

（構成）請求項１６記載の発明に対応する実施の形態を、図１３に従って以下に説明する。本実施の形態の基本構成は、第１の実施の形態と同様であるが、反応ガスを電池スタック１内を通して予熱した後、加湿するようにしている点が異なる。すなわち、燃料ガス供給管２及び空気供給管３は、電池スタック１内に設けられた予熱ダクト４０，４１を貫通している。そして、予熱ダクト４０，４１から出た燃料ガス供給管２及び空気供給管３には、水蒸気の入り口６，７が設けられ、さらに電池スタック１内に導かれている。

【００７８】（作用）以上のような本実施の形態では、燃料ガス供給管２及び空気供給管３より供給された燃料ガスと空気は、電池スタック１内に設けられた予熱ダクト４０，４１を通って予熱される。そして、電池スタック１の外部にて水蒸気発生器５により加湿された後、電池スタック１内に導かれ、反応する。

【００７９】（効果）以上のような本実施の形態によれば、反応ガスが予熱され温度が高い状態で水蒸気が供給されるため、反応ガス内に噴出された水蒸気は凝縮しにくくなり、より広範囲の温度領域で効果的な加湿が可能となる。また、反応ガスの予熱には、電池スタック１の発電により生じた熱を用いるので、効率的である。

【００８０】（１１）他の実施の形態

本発明は以上のような実施の形態に限定されるものではなく、各部材の構成は適宜変更可能である。例えば、請求項４記載の発明に対応する実施の形態として、第２の

実施の形態における湿度センサー１３，１４の代わりに、電池スタック１の電流を測定する電流センサーを用いても、加湿量決定のための情報とすることができる。すなわち、加湿量はほぼ負荷量に比例するため、予め比例常数を設定すれば、最適な湿度とするために必要な加湿量を算出できることになる。

【００８１】さらに、システム上、負荷量は利用する側から決定される場合が多いので、その場合には、制御装置１２が負荷量を把握していることになり、センサーを用いない場合であっても、ある程度の制御が可能となる。

【００８２】また、請求項５及び請求項６記載の発明に対応する実施の形態として、湿度センサーの代わりに燃料ガスの流量センサーを用いても、加湿量決定のための情報とすることができる。すなわち、加湿量はほぼ燃料流量に比例するため、予め比例常数を設定すれば、最適な湿度とするために必要な加湿量を算出できることになる。空気流量についても全く同様のことが言える。

【００８３】さらに、システム上、負荷量は利用する側から決定される場合が多く、負荷量はまた反応ガス量にほぼ比例するので、その場合は制御装置１２が反応ガス量を把握していることになり、センサーを用いない場合であっても、ある程度の制御が可能である。

【００８４】また、請求項８記載の発明に対応する実施の形態として、上記の第３の実施の形態における加圧ポンプ２０の代わりに、水蒸気発生装置５を設けることも可能である。また、上記の第３～６の実施の形態では、燃料ガス側の加湿を行っているが、同様の方法で空気側の加湿を行うことも可能である。また、上記の第９の実施の形態では、電池の作動状態として、代表的な電池スタック１の状態をモニターしているが、複数の電池スタック１，３５の平均の値を採用してもよい。また、加湿状態をモニターする手段としては、第２の実施の形態で述べたような湿度センサーを用いてもよく、流量センサーを用いてもよい。さらに、加湿手段としては、図１２に示す水蒸気発生器に限定されることはなく、第３～６の実施の形態で述べたような種々の加湿手段が適用できる。

【００８５】また、第１０の実施の形態では、第３～６の実施の形態において示した微粒化された水を用いた場合にも、水の蒸発がより一層促進されるため、周囲に水が凝縮するようなことがなく、より確実な加湿が可能となる。予熱手段として、冷却水と反応ガスとの熱交換器を用いてもよい。

【００８６】

【発明の効果】以上説明したように、本発明によれば、固体高分子電解質膜に適度な水分を与え、負荷条件等作動条件が変化しても、燃料電池として最適な状態で動作できるように、反応ガスへの加湿量をコントロール可能な固体高分子電解質型燃料電池システムを提供することができる。また、小形化、軽量化及び低コスト化が可能な固体高分子電解質型燃料電池システムを提供することができる。

【図面の簡単な説明】

【図１】本発明の固体高分子電解質型燃料電池システムの第１の実施の形態を示す構成図である。

【図２】図１の実施の形態における加湿制御の基本シーケンスを表す流れ図である。

【図３】本発明の固体高分子電解質型燃料電池システムの第２の実施の形態を示す構成図である。

【図４】本発明の固体高分子電解質型燃料電池システムの第３の実施の形態を示す構成図である。

【図５】図４の実施の形態における噴霧ノズル近傍の燃料ガス供給管を示す断面図である。

【図６】本発明の固体高分子電解質型燃料電池システムの第４の実施の形態を示す構成図である。

【図７】図６の実施の形態における超音波ノズル近傍の燃料ガス供給管を示す断面図である。

【図８】本発明の固体高分子電解質型燃料電池システムの第５の実施の形態における絞り部近傍の燃料ガス供給管を示す断面図である。

【図９】本発明の固体高分子電解質型燃料電池システムの第６の実施の形態における回転霧化装置近傍の燃料ガス供給管を示す断面図である。

【図１０】本発明の固体高分子電解質型燃料電池システムの第７の実施の形態を示す構成図である。

【図１１】本発明の固体高分子電解質型燃料電池システムの第８の実施の形態を示す構成図である。

【図１２】本発明の固体高分子電解質型燃料電池システムの第９の実施の形態を示す構成図である。

【図１３】本発明の固体高分子電解質型燃料電池システムの第１０の実施の形態を示す構成図である。

【図１４】従来の燃料電池の単電池構造の一例を表す断面図である。

【図１５】電池スタック内部に加湿部分を持つ従来の燃料電池システムの一例を示す側面図である。

【図１６】加湿装置としてバブラーを備えた従来の燃料電池システムの一例を示す構成図である。

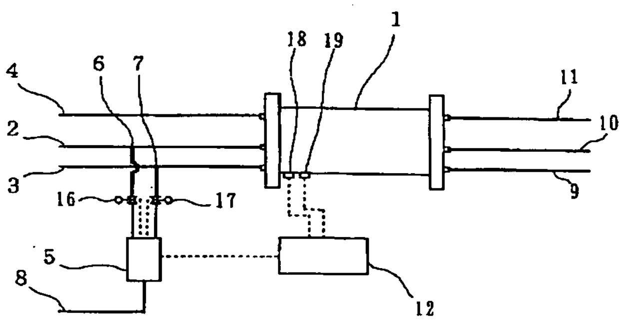
【図１７】加湿装置として超音波霧化装置を備えた従来の電池スタックの一例を示す断面図である。

【符号の説明】

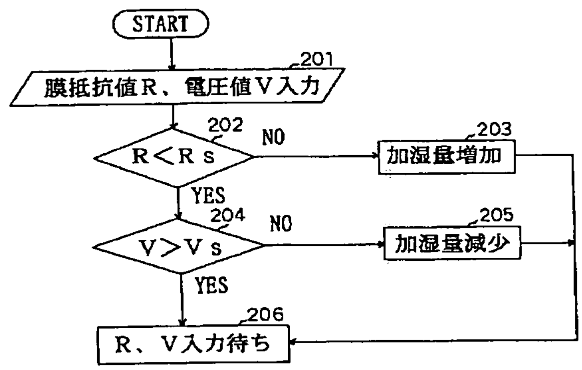
１，３５…電池スタック
２…燃料供給管
３…空気供給管
４…冷却水供給管
５…水蒸気発生装置
６，７…水蒸気入り口
８，２２…水供給管
９，３００…空気排出管
１０，３０１…燃料ガス排出管

１１，３０２…冷却水排出管
１２…制御装置
１３，１４…湿度センサー
１６，１７，２３，３２…流量制御弁
１８…抵抗値センサー
１９…電圧センサー
２０…高圧ポンプ
２１…噴霧ノズル
２４…超音波ノズル
２５…水噴出口
２６…絞り部
２７…回転円盤
２８…モーター
２９…霧化室
３０…循環ポンプ
３１…ラジエーター
３３…冷却水戻り管
３４…気液分離器
３７，３８，３９…分岐部
４０，４１…予熱ダクト
１０１…単電池
１０２…固体高分子膜
１０３…アノード電極
１０３ａ…アノード触媒層
１０３ｂ…アノード多孔質カーボン平板
１０３ｃ…燃料供給溝
１０４…カソード電極
１０４ａ…カソード触媒層
１０４ｂ…カソード多孔質カーボン平板
１０４ｃ…酸化剤供給溝
１０５…セパレータ

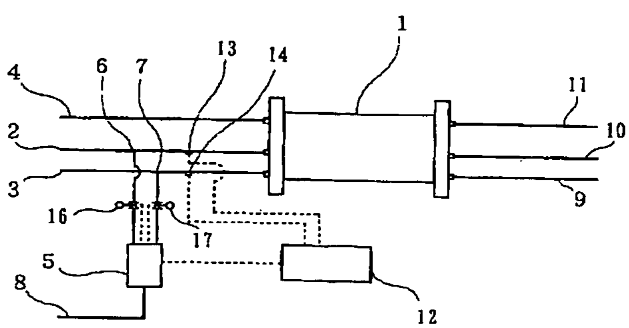
【図１】




【図２】




【図３】

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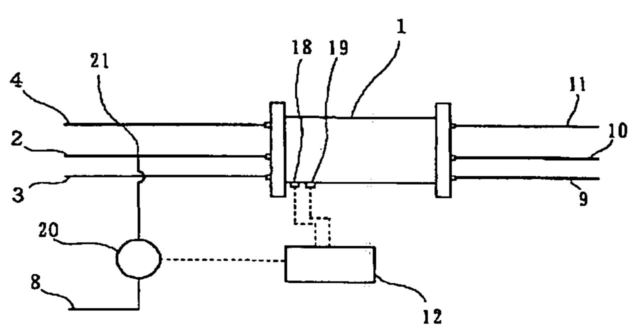

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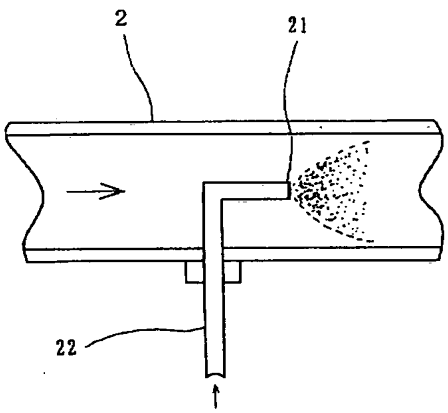

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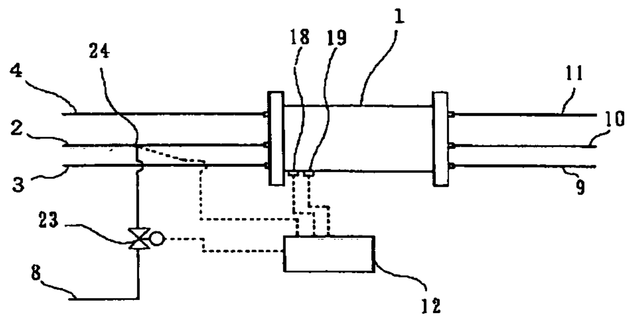

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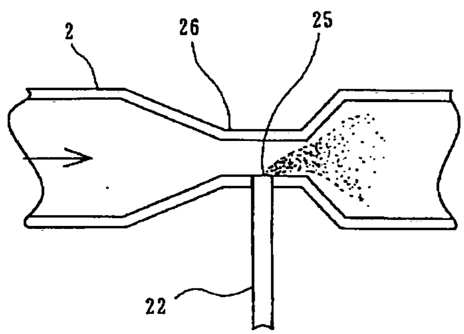

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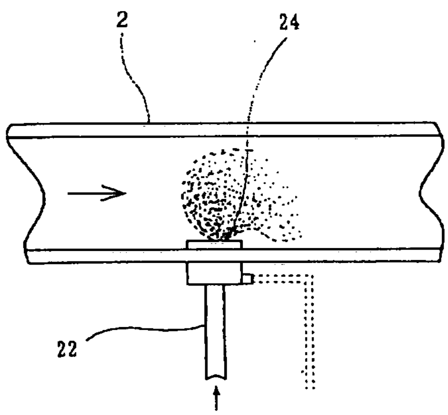
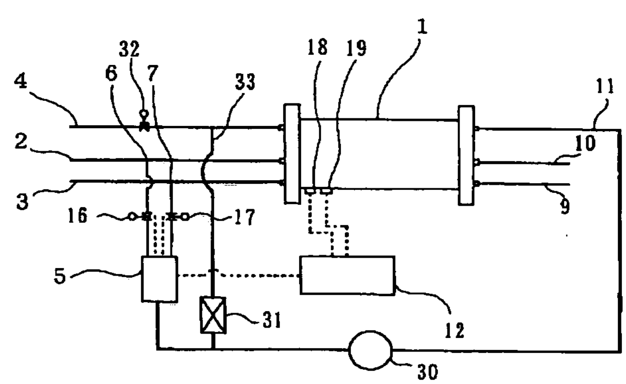
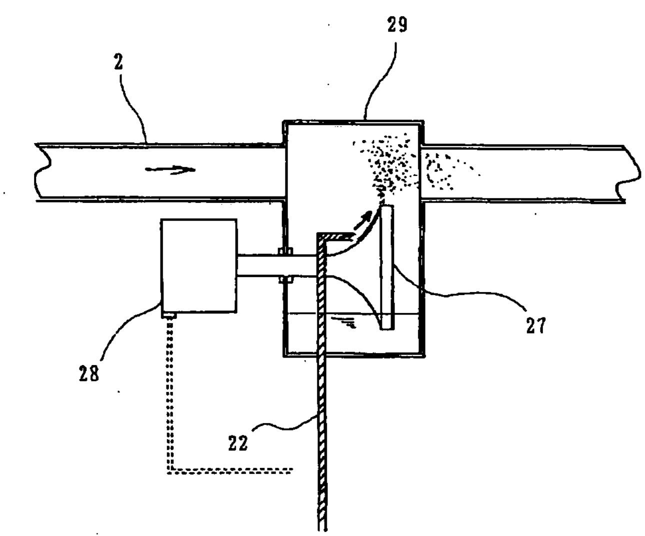


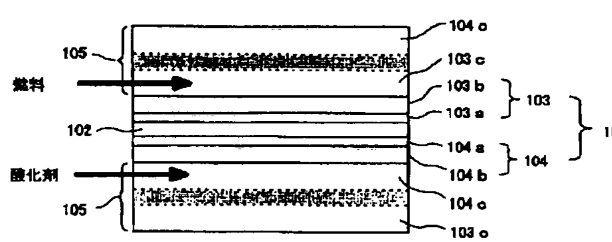
【図１０】



【図９】



【図１４】



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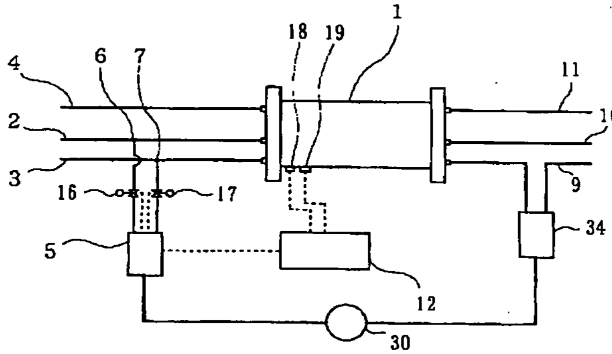


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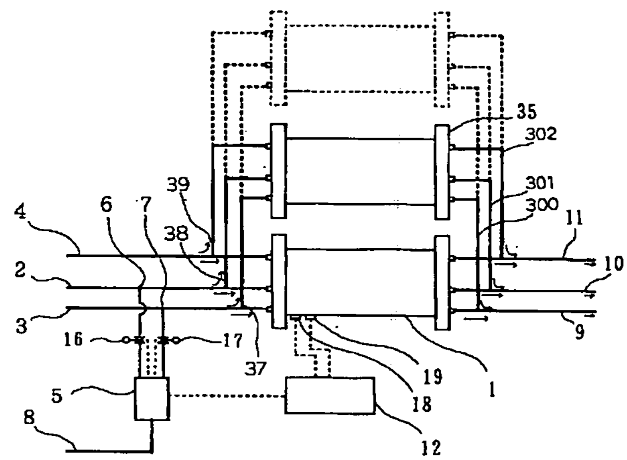


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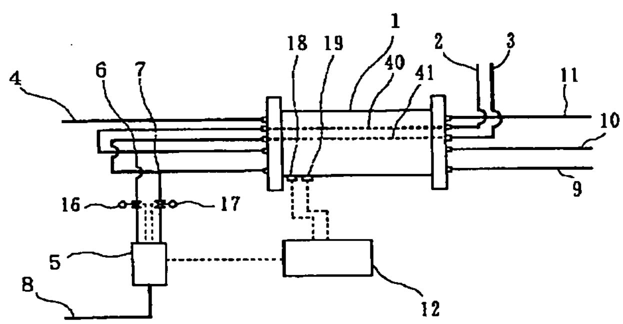
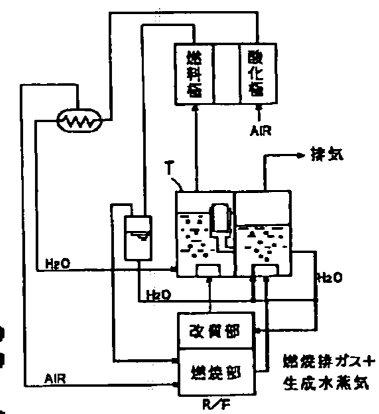



【図１６】

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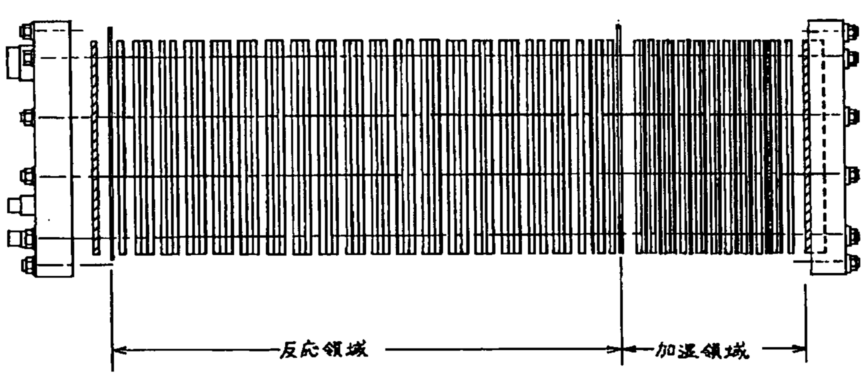
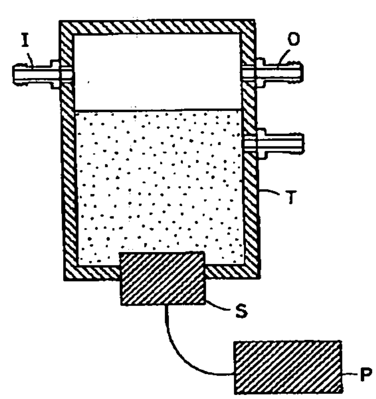



【図１７】



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